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OBSERVATIONS ON BIOMETRICAL PARAMETERS IN ELASMOBRANCH SPECIES FROM MAGHREBIN WATERS: A SURVEY

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ABSTRACT

Investigations conducted off the Maghrebin shore from 1969 to date allow us to observe significant changes in some biometrical parameters, such as size at sexual maturity and maximal size involving sexual dimorphism in size. Generally, the latter are larger than the former, and this phenomenon is more evident in viviparous than oviparous species. For instance, in some scyliorhinid species, males are larger than females. Environmental parameters could have an effect on the size at sexual maturity and maximal size in elasmobranch oviparous species; in the same species, specimens from cold areas are smaller than those from warmer waters. Similar patterns were not clearly observed in viviparous species and need further observations.

Key words: Elasmobranchs, sexual dimorphism, reproduction, Maghrebin waters, Mediterranean

ALCUNE CONSTATAZIONI SUI PARAMETRI BIOMETRICI DI SQUALI E RAZZE NELLE ACQUE MAGREBINE: RASSEGNA

SINTESI

Grazie alle ricerche effettuate nelle acque magrebine a partire dal 1969, è stato possibile osservare alcuni cambiamenti nei parametri biometrici degli squali e delle razze, come ad esempio la dimensione nella fase di maturità sessuale e la grandezza massima nel dimorfismo sessuale. In generale, gli esemplari più recenti sono di dimensioni maggiori rispetto a quelli precedenti, un fenomeno che è più evidente per le specie vivipare rispetto a quelle ovovivipare. Per esempio, presso alcune specie della famiglia dei gattucci Scyliorhinidae, i maschi sono più grandi delle femmine. Sulle dimensioni nella fase di maturità sessuale e sulla grandezza massima delle specie ovovivipare degli squali e delle razze potrebbe esserci un'influenza dei parametri ambientali; tra gli esemplari della stessa specie, quelli provenienti da acque fredde sono più piccoli di quelli che vivono in zone più calde. Campioni del genere o analoghi non sono stati registrati presso le specie vivipare e richiedono ulteriori ricerche.

Parole chiave: squali e razze, dimorfismo sessuale, riproduzione, acque magrebine, Mediterraneo

INTRODUCTION

Intraspecific geographic changes in size were suspected in rajid species by Borcéa (1906) and in scyliorhinid species by Fauré-Frémiet (1942): the Mediterranean specimens being smaller than the Atlantic ones. Similar patterns were also described by Leloup & Olivereau (1951) in scyliorhinids, such as the smallspotted catshark, *Scyliorhinus canicula* and the nursehound *S. stellaris*. They also suggested that the Mediterranean specimens matured at smaller size than the Atlantic ones and reached a smaller maximal size, with these changes due to environmental influences, especially light and temperature. Nevertheless, Dodd (1983) noted: *"Nothing is known of environmental influences on reproduction in viviparous species; however, the precision of the timing of their annual and biannual cycles indicates that such influences may play an important role in reproduction".*

Moreover, elasmobranch species show sexual dimorphism in size, females reach a larger maximal size than males, as they mature at a larger size. By contrast, it appears that in some species this was not exactly the case (Mellinger, 1989; Simpfendorfer & Unsworth, 1998).

Investigations conducted in the period of thirty years off the Maghrebin shore allow us to examine oviparous and viviparous elasmobranch species and to give, for several species, size at sexual maturity and maximal size for both males and females. The results are summarized and commented in this article.

MATERIAL AND METHODS

Investigations were conducted between 1969 and 2003 off the Maghrebin shore, off the Tunisian coast from the Libyan to the Algerian borders, and between 1996 and 2003 off the Algerian coast, from the Tunisian to the Moroccan borders (Fig. 1).

Observations were made at Algiers, Annaba, Tunis and Sfax fish markets: elasmobranchs were landed as by-catch species, rarely as targeted species. The observed specimens were collected by commercial vessels. They were caught by trawling, occasionally by bottom longlines, drift-lines and gill-netters. Moreover, specimens captured by artisanal fisheries, such as gill nets, seines, bottom longlines and anglers, were also observed at fishing sites along the Maghrebin shore.

In addition, data collected from elasmobranch species caught between 1988 and 2003 off the coast of Languedoc, southern France, and between 1993 and 2003 off the coast of Senegal, eastern tropical Atlantic, are also included in this article. As far as the first area is concerned, specimens were caught by trawling and craft fisheries, occasionally by artisanal fisheries, while in the second area all the specimens were caught by craft fisheries.

The onset of sexual maturity was studied in males and in females, separately.

Sexual maturity in males was determined from the size and condition of the claspers (Fig. 2). The size of claspers was measured following Collenot (1969) from the metapterygium to the tip of claspers. The relationship clasper-length (CL) *versus* total length (TL) was analysed in sharks, rhinobatids and torpedinids, the relationship clasper-length *versus* disk-width (DW) in skates and rays.

The linear regression was expressed in arithmetical co-ordinates: $y = bx^a$, $CL = bTL^a$ or $CL = b\ DW^a$, or in decimal logarithmic co-ordinates as log CL = a log TL + log b (Fig. 3), or log CL = a log DW + log b (Fig. 4).

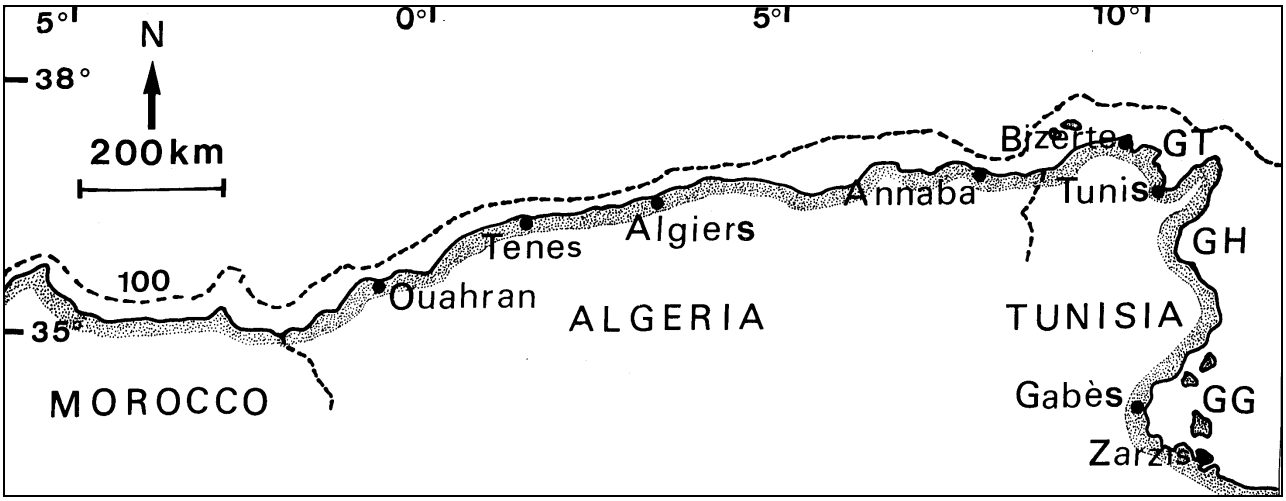

Fig. 1: Map of Maghrebine waters showing both the fishing site landings and observation sites of elasmobranch species.
Sl. 1: Zemljevid magrebskih voda z lokalitetami ulova morskih psov in skatov ter preučevanih območij.

In elasmobranch species, there are apparently no seasonal variations in clasper length according to Mellinger (1989). The CL to TL relationship shows two inflexions indicating the three stages of sexual development in males: juvenile, sub-adult and adult. During the first stage, the claspers grow allometrically and this is also the case in adults, throughout their life. By contrast, the claspers grow fastest during the second stage that could also be considered a maturation stage (Figs. 3, 4).

In order to avoid underestimation of size at sexual maturity, the condition of claspers was also examined. Three reproductive stages were recognized (Capapé *et al.*, 1990; Bridge *et al.*, 1998): juvenile, with claspers short, flexible and not calcified; sub-adult, with slight calcification of claspers; adult, with claspers elongated, rigid and completely calcified (Fig. 5).

Other features were used in order to complete the delineation of the onset of sexual maturity, such as condition of testes and genital duct. In juveniles, both testes and genital duct were membranous and inconspicuously developed.

During the sub-adult stage, the testes were developed, but without spermatocysts externally visible and no sperm in seminal vesicles. The genital duct was developed and the *ductus deferens* (*sensu* Hamlett *et al.*, 1999a) slightly convoluted.

During the adult stage, both testes and genital duct were well developed. Spermatocysts externally visible and sperm occurred in seminal vesicles. The *ductus deferens* was clearly twisted.

Similar to the males, three categories of females were considered: juvenile, sub-adult and adult. The onset of sexual maturity in females could be determined by using vagina length *versus* total length or disk-width according to Steven (1936). The linear regression could be expressed in arithmetical co-ordinates or in decimal logarithmic co-ordinates. This method is useful but it must be only used in fresh specimens immediately observed after their capture. However, the vagina could be retracted after their death or distended after parturition. This method was used only for the marbled torpedo *Torpedo marmorata*.

Size at sexual maturity in females was assessed by examination of ovaries, oviducal glands and genital duct (see Hamlett *et al.*, 1999b).

During the juvenile stage, females had whitish ovaries, oocytes of only microscopic size, membrane-like oviducts and inconspicuous oviducal glands. Sub-adult females exhibited primarily white, translucent oocytes, a well-differentiated genital duct and oviducal glands visible and slightly rounded. In adult females, developing oocytes were observed in non-gravid females. The genital tract was fully developed and in some specimens both uteri contained eggs or embryos at different stages of development.

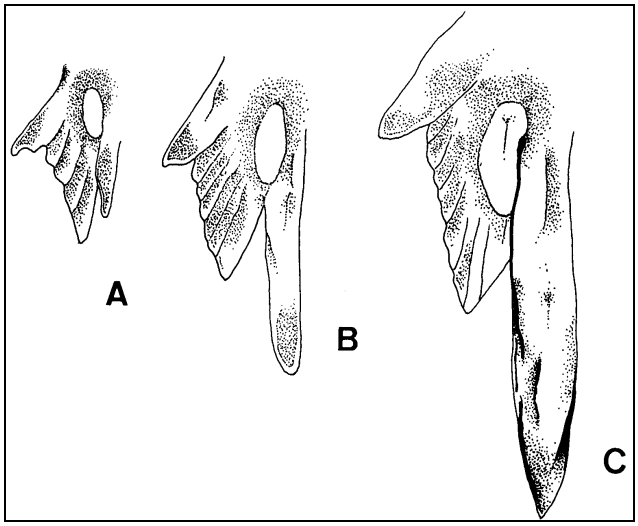

Fig. 2: Morphology of claspers observed in the rough ray, *Raja radula****, during the three stages of development: A – juvenile, B – sub–adult, C – adult.***
Sl. 2: Morfologija spolnih organov vrste *Raja radula* ***v treh stopnjah njenega razvoja: A – mladostni osebek, B – skoraj odrasel osebek, C – odrasel osebek.***

RESULTS AND DISCUSSION

All the results are summarized in Tables 1, 2 and 3. They show that among the scyliorhinid, species size at sexual maturity are different between specimens from the Atlantic and those from the Tunisian coast, corroborating the previous observations of Leloup & Olivereau (1951). Therefore, the specimens from the Tunisian coast matured at a smaller size and reach a smaller size than those from the Atlantic. By contrast, different patterns were observed between *S. canicula* from the Tunisian and Languedocian coasts. This suggests that the *S. canicula* from the Atlantic and the Mediterranean could be at least two different forms of *S. canicula*, an Atlantic form and a Mediterranean form, as this was probably the case for *Dasyatis centroura* (see Capapé, 1993). Moreover, the biometrical changes observed between the *S. canicula* from off Tunisia and from off the Languedocian coast suggest the occurrence of different populations in these two Mediterranean areas. Nevertheless, this opinion requires further investigations, as it could not be based only on biometrical parameters. By contrast, the latter ones played an important role and contribute to separate three sympatric dasyatid species recorded in Tunisian waters, *Dasyatis pastinaca*, *D. tortonesei* and *D. marmorata*, which show significant differences between them regarding the size at sexual maturity and maximal size (Tab. 3).

In migratory large sharks, such as carcharhinid species, *Carcharhinus brevipinna, C. limbatus* and *C. plumbeus*, significant changes in size at sexual maturity and

Tab. 1: Size (in mm) at sexual maturity (sex. m.) and maximal size (max. size) in males and females of ten oviparous elasmobranch species.
Tab. 1: Velikost (v mm) pri spolni zrelosti (sex. m.) in maksimalna velikost (max. size) samcev in samic desetih jajcerodnih vrst morskih psov in skatov.

Species	Males		Females		Areas	References
	sex. m.	max. size	sex. m.	max. size		
Scyliorhinus canicula	400	530	350	430	Northern Tunisia	Capapé (1977b)
	440	550	410-470	510	Gulf of Lion	Capapé *et al.* (1991)
S. stellaris	800	1080	820	1150	Northern Tunisia	Capapé (1977c)
Galeus melastomus	430	620	460	660	Northern Tunisia	Capapé & Zaouali (1977)
Raja miraletus	230	320	240-280	330	Gulf of Tunis	Capapé & Quignard (1974a)
R. clavata	480	540	490	570	Northern Tunisia	Capapé (1976b)
R. asterias	370	420	440	450	Northern Tunisia	Capapé (1977a)
R. radula	330	380	360	420	Northern Tunisia	Capapé (1974a)
R. polystigma	340	450	380	410	Northern Tunisia	Capapé & Quignard (1978)
R. melitensis	190	220	230	240	Northern Tunisia	Capapé (1977d)
R. alba	910	1160	980	1280	Northern Tunisia	Capapé (1976c)

in maximal size were not observed between specimens from Tunisian coastal waters and those from other marine areas, *e.g.* South Africa (Bass *et al.*, 1973), Australia (Stevens & McLoughlin, 1991), Senegal (Cadenat & Blache, 1981; Capapé *et al.*, 2003c), Gulf of Mexico (Branstetter, 1981) and probably throughout the world (Garrick, 1982; Compagno, 1984a, b). During their migration, these species seek waters where environmental parameters are practically homogeneous and pregnant females ending gestation approach nurseries where neonates could find sufficient food to assume the first period of their extra-uterine life, as well as could avoid the predation risk of adult sharks (Muñoz-Chapuli, 1984).

A comparison between data collected from the same species caught off the Tunisian and Senegalese coasts (see Capapé *et al.*, 1996) show that these species could be divided into three categories: the first category comprises the species, whose specimens, caught off Tunisia, are larger than those caught off Senegal: *Mustelus mediterraneus*, *T. marmorata*, *Rhinobatos rhinobatos* and *Pteromylaeus bovinus*.

By contrast, the second category includes species, whose specimens, caught off Senegal, are larger than those caught off Tunisia: *Squatina oculata*, *R. cemiculus*, *Raja miraletus*, *Torpedo torpedo*, *Dasyatis chrysonota* and *D. tortonesei*.

The third category comprises species which do not show changes in size at sexual maturity and maximal size in both areas, with the three carcharhinid species cited above among them, *C. brevipinna*, *C. limbatus* and *C. plumbeus*, *Oxynotus centrina*, *Etmopterus spinax* and *Squatina aculeata*.

These observations are not completely in agreement with Leloup & Olivereau's opinion (1951). Moreover, specimens of the single oviparous species, *R. miraletus* captured off Senegal are larger than those captured off Tunisia, while water temperature is higher along the Senegalese coast, than Tunisian waters.

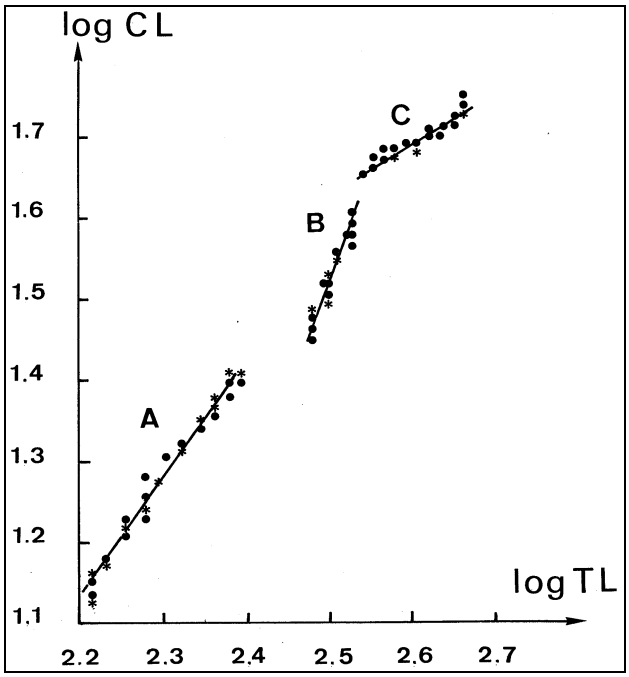

Fig. 3: Velvet belly** Etmopterus spinax **from the Mediterranean. Clasper length (CL)** vs. **total length (TL) expressed in decimal logarithmic coordinates: A – juvenile stage, B – sub–adult stage, C – adult stage (redrawn from Capapé** et al.**, 2001a).
Sl. 3: Žametni morski pes** Etmopterus spinax**. Dolžina spolnega organa (CL) v primerjavi s celotno dolžino (TL), izražena v decimalnih logaritmičnih koordinatah: A – mladostni osebek, B – skoraj odrasli osebek, C – odrasel osebek (povzeto po Capapé** et al.**, 2001a).

Tab. 2: Size (in mm) at sexual maturity (sex. m.) and maximal size (max. size) in males and females of fifteen viviparous shark species.
Tab. 2: Velikost (v mm) pri spolni zrelosti (sex. m.) in maksimalna velikost (max. size) samcev in samic petnajstih živorodnih vrst morskih psov.

Species	Males		Females		Areas	References
	sex. m.	max. size	sex. m.	max. size		
Heptranchias perlo	930	1180	1050	1390	NorthernTunisia	Capapé (1980)
Hexanchus griseus	3540	5000?	3940	5000?	Mediterranean	Capapé *et al.* (2003a)
Galeorhinus galeus	1130	1780	1250	1950	Gulf of Tunis	Capapé & Mellinger (1988)
Mustelus asterias	760	1260	800	1280	Gulf of Tunis	Capapé (1983)
M. mediterraneus	910	1820	1040	1910	Tunisia	Capapé & Quignard (1977)
Carcharhinus plumbeus	1670	2250	1710	2480	Gulf of Gabès	Capapé (1984)
C. brevipinna	1720	1960	2630	2750	Tunisia	Capapé *et al.* (2003c)
C. limbatus	1670	2160	1780	2450	Senegal	Capapé *et al. (in press* a)
Oxynotus centrina	600	650	640	780	Mediterranean	Capapé *et al.* (1999b)
Centrophorus granulosus	810	1250	800	1250	NorthernTunisia	Capapé (1985)
Squalus blainvillei	510	640	700	840	Gulf of Tunis	Capapé (1974b)
Etmopterus spinax	380	460	400	460	NorthernTunisia	Capapé *et al.* (2001a)
Squatina aculeata	1200	1370	1520	1750	Senegal-Tunisia	Capapé *et al. (in press* b)
S. oculata	710	1210	900	1210	Gulf of Tunis	Capapé *et al.* (1990)
	820	1450	890	1570	Senegal	Capapé *et al.* (2002)
S. squatina	800	1320	1280	1690	Gulf of Tunis	Capapé *et al.* (1990)

The environmental factors probably play a role with regard to size at sexual maturity and maximal size in elasmobranch species but remain difficult to be determined. However, the biological environment cannot be neglected. It appears more important and diversified in eastern tropical Atlantic waters than in the Mediterranean waters. The competition pressure for food seems to be less evident in the first than in the second area (Diatta *et al.*, 2001, 2002). Moreover, Capapé *et al.* (2003b) showed that the reproductive mode considerably reduced intraspecific and interspecific competition for food in deep-sea waters, where the biological environment is poorly represented. Consequently, if the role of both environmental and biological factors could not be totally neglected, it formed the object of changes according to the species. This could explain, *pro parte*, why *R. miraletus* specimens from Senegal waters are larger than Tunisian specimens, and why, by contrast, this is not the case for *M. mediterraneus*, caught in both same areas.

Cadenat & Blache (1981) suggested the hypothesis of distinct subspecies or at least distinct forms, such as for the spinner shark *C. brevipinna* from the coastal waters of Senegal. Similar patterns were observed for *D. centroura* by Capapé (1993) and Hemida *et al.* (2003) for the pelagic stingray *D. violacea*.

Moreover, there are not only intraspecific changes in size related to the area. In agreement with Mellinger *et al.*'s opinion (1984), larger specimens produce larger eggs and larger neonates; moreover, in numerous species fecundity is related to mother's size. In most elas-

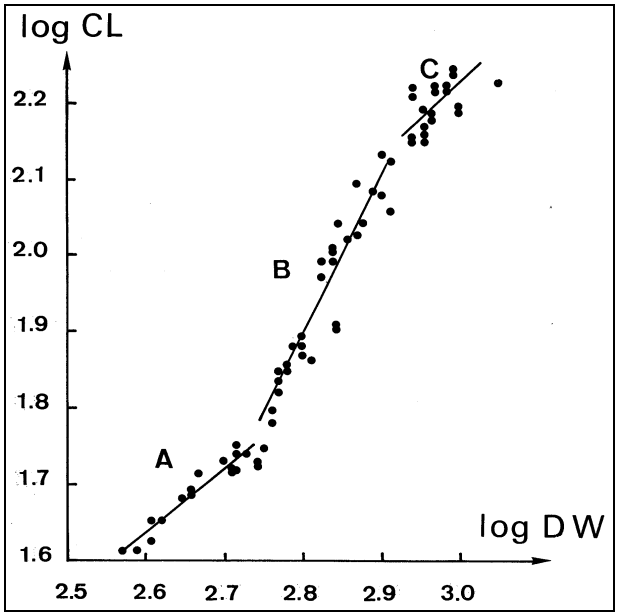

Fig. 4: Butterfly ray** Gymnura altavela **from Tunisian coastal waters. Clasper length (CL)** vs. **disk width (DW) expressed in decimal logarithmic coordinates: A – juvenile stage, B – sub–adult stage, C – adult stage (redrawn from Capapé** et al.**, 1992).
Sl. 4:** Gymnura altavela **iz tunizijskih voda. Dolžina spolnega organa (CL) v primerjavi s širino diska (DW), izražena v decimalnih logaritmičnih koordinatah: A – mladostni osebek, B – skoraj odrasli osebek, C – odrasel osebek (povzeto po Capapé** et al.**, 1992).

Tab. 3: Size (in mm) at sexual maturity (sex. m.) and maximal size (max. size) in males and females of thirteen viviparous ray species.
Tab. 3: Velikost (v mm) pri spolni zrelosti (sex. m.) in maksimalna velikost (max. size) samcev in samic trinajstih živorodnih vrst skatov.

Species	Males		Females		Areas	References
	sex. m.	max. size	sex. m.	max. size		
Rhinobatos rhinobatos	750	1400	850	1620	Gulf of Tunis	Capapé *et al.* (1997)
	660	1180	780	1530	Senegal	Capapé *et al.* (1999a)
R. cemiculus	1010	1920	1010	1950	Gulf of Gabès	Capapé & Zaouali (1994)
	1550	1630	2330	2450	Senegal	Seck *et al.* (*in press*)
Torpedo mackayana	315	350	382	500	Senegal	Capapé *et al.* (2000a)
T. marmorata	290	340	395	580	Gulf of Tunis	Capapé (1979)
	270	380	260	580	Senegal	Capapé *et al.* (2001b)
T. torpedo	160	290	190	360	Gulf of Tunis	Quignard & Capapé (1974)
	230	365	230	410	Gulf of Gabès	Ennajar *et al.* (2002)
	300	310	445	550	Senegal	Capapé *et al.* (2000b)
Dasyatis centroura	800	1000	1040	1345	Tunisia	Capapé (1993)
D. chrysonota	300	320	400	440	Gulf of Gabès	Capapé & Zaouali (1995)
D. pastinaca	310	570	380	680	Gulf of Tunis	Capapé (1976a)
D. tortonesei	380	570	460	600	Tunisia	Capapé (1978)
D. violacea	420	580	450	610	Mediterranean	Hemida *et al.* (2003)
Gymnura altavela	780	1000	1140	1620	Tunisia	Capapé *et al.* (1992)
Myliobatis aquila	410	550	580	850	Gulf of Tunis	Capapé & Quignard (1974b)
Pteromylaeus bovinus	800	1600	1000	>2000	Gulf of Gabès	Capapé & Quignard (1975)
	820	1150	900	1480	Senegal	Seck *et al.* (2002)

mobranch species we have generally observed a relationship size *versus* ovarian and uterine fecundity. Both categories of fecundity increased with mother's size and in the same species intraspecific changes appeared according to the area with regard to fecundity. For instance, common torpedoes from Senegal (Capapé *et al.*, 2000b) were larger than those of Tunisia, Gulf of Tunis (Quignard & Capapé, 1974) and Gulf of Gabès (Ennajar *et al.*, 2002). It is interesting to note that the specimens from the Gulf of Tunis live in temperate waters, the specimens from the Gulf of Gabès in subtropical waters, and those of Senegal in tropical waters. Moreover, the greatest common torpedoes were observed in the Gulf of Lion *(unpubl. data),* although the waters of this latter area are slightly colder than those of the three previous areas.

With regard to sexual dimorphism in size, Tables 1, 2 and 3, show that females are larger than males and reach a larger size, except in *S. canicula*. Mellinger (1989) noted that similar patterns were observed in other scyliorhinid species. By contrast, to our knowledge, this phenomenon was not reported in other oviparous elasmobranch species. For instance, in rajid species, males are significantly smaller than females because they matured at a smaller size; moreover, sexual dimorphism in size appears to be related to the species size (Capapé, 1977d). However, sexual dimorphism in size is more evident in the largest rajid species, such as *R. clavata*, than in the smallest species, such as *R. melitensis*, as this was reported for specimens from Tunisian waters (Capapé, 1977d).

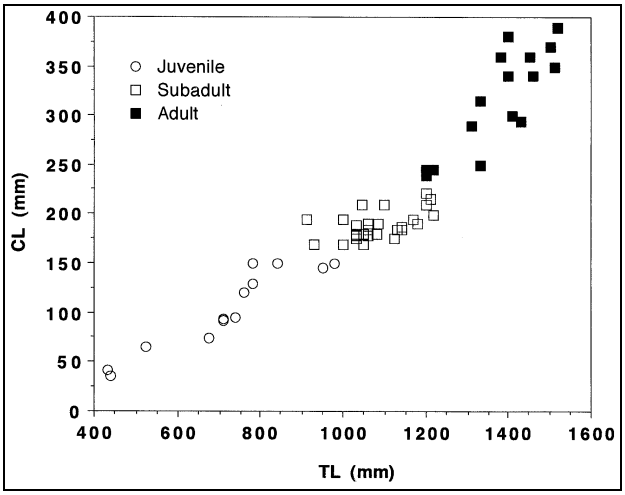

Fig. 5: Clasper length (CL)** vs. **total length (TL) in male** Squatina aculeata **based on the condition of the claspers (redrawn from Capapé** et al.**,** in press **b).
Fig. 5: Dolžina spolnega organa (CL) v primerjavi s celotno dolžino (TL) pri samcu vrste** Squatina aculeata **na osnovi stanja spolnih organov (povzeto po Capapé** et al.**,** in press **b).

Sexual dimorphism in size is especially marked in viviparous species. This is due to the fact that the females carried the brood during all the gestation and consequently contributed to the development of embryos by providing organic and inorganic nutrients. Nevertheless, our observations showed that in carcharhinid species, the phenomenon is less marked than in dasyatids, gymnurids and myliobatids. For instance, the female bull rays, *Myliobatis aquila* and *P. bovinus*, exhibit internal uterine wall which was strongly developed at gestation end with the presence of uterine villi providing uterine milk for embryos (Hamlett *et al.*, 1985). This could explain why these species had a short gestation period, which lasted between two and six months (Ranzi & Zezza, 1936; Capapé & Quignard, 1974a, b, 1975; Hemida *et al.*, 2003) *vs.* one year, at least, in carcharhinid species (Capapé *et al.*, 2003c).

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NEKAJ UGOTOVITEV GLEDE BIOMETRIČNIH PARAMETROV PRI MORSKIH PSIH IN SKATIH IZ MAGREBSKIH VODA: PREGLED

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POVZETEK

Po zaslugi raziskav, opravljenih v magrebskih vodah vse od leta 1969 pa do danes, je bilo mogoče zaslediti nekaj pomembnih sprememb v biometričnih parametrih morskih psov in skatov, kot na primer v velikosti, ko dosežejo spolno zrelost, in maksimalni velikosti pri spolnem dimorfizmu. Na splošno so novejši primerki večji kot starejši, ta pojav pa je bolj očiten pri živorodnih kot jajcerodnih vrstah. Pri nekaterih vrstah iz družine morskih mačk Scyliorhinidae, na primer, so samci večji od samic. Na velikost ob spolni zrelosti in maksimalno velikost pri jajcerodnih vrstah morskih psov in skatov bi utegnili vplivati okoljski parametri; med osebki iste vrste so manjši tisti iz mrzlih voda kot tisti iz toplejših območij. Takšnih ali podobnih vzorcev ni bilo zaslediti pri živorodnih vrstah in terjajo nove raziskave.

Ključne besede: morski psi in skati, spolni dimorfizem, razmnoževanje, magrebske vode, Sredozemlje

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CATTURE ED AVVISTAMENTI DI MÒBULA, *MOBULA MOBULAR* (BONNATERRE, 1788) NELLE ACQUE DELLO STRETTO DI MESSINA

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SINTESI

E' stato condotto uno studio sulla presenza della mòbula, Mobula mobular, *nello Stretto di Messina, raccogliendo testimonianze relative a 50 esemplari (5 catturati e 45 avvistati) nel periodo 1990–2003 (con l'eccezione di un caso datato 1970). I dati raccolti mostrano che tale specie è presente nell'area con costanza, in particolare tra tarda primavera ed estate, allorquando gli esemplari osservati si muovono verso Nord, solitamente in gruppi composti da 5 a 6 individui. Sono stati osservati casi di predazione su clupeiformi ed eufasiacei, ed è stato analizzato il contenuto stomacale di uno degli individui pescati. E' stato osservato che le mòbule sono sovente accompagnate da altre specie: balenottera comune* (Balaenoptera physalus), *tursiope (*Tursiops truncatus*), stenella striata* (Stenella coeruleoalba), *tonno* (Thunnus thynnus), *aguglia imperiale* (Tetrapturus belone), *e pesci pilota* (Naucrates ductor). *Gli esemplari catturati erano tutti di sesso femminile, lasciando supporre che* M. mobular *presenti segregazione sessuale.*

Parole chiave: mòbula, *Mobula mobular*, pesca, comportamento, alimentazione, Mare Mediterraneo

CAUGHT AND OBSERVED GIANT DEVIL RAYS *MOBULA MOBULAR* (BONNATERRE, 1788) IN THE STRAIT OF MESSINA

ABSTRACT

A study on the presence of the giant devil ray, Mobula mobular, *in the Strait of Messina has been conducted on the basis of information collected for 50 individuals (5 captured and 45 sighted) during the 1990–2003 period (with the exception of the case dated 1970). The collected data show that this species is regularly present in the studied area, especially between late spring and summer, when giant devil rays move north, usually in groups composed of 5 to 6 individuals. Predation on clupeiformes and euphasiaceans has been observed, and stomach contents of a specimen has been analysed. Giant devil rays are often accompanied by other species, including the fin whale (*Balaenoptera physalus*), bottlenose dolphin* (Tursiops truncatus), *striped dolphin* (Stenella coeruleoalba), *bluefin tuna* (Thunnus thynnus), *Mediterranean spearfish* (Tetrapturus belone), *and the pilotfish* (Naucrates ductor). *All caught specimens were females and that may indicate some form of sex segregation.*

Key words: giant devil ray, *Mobula mobular*, fishery, behaviour, feeding, Mediterranean Sea

INTRODUZIONE

La mòbula, *Mobula mobular* (Bonnaterre, 1788), è il più grande batoideo presente nel Mediterraneo, il cui disco può raggiungere una larghezza di circa 500 cm, anche se solitamente non supera 300 cm. Il capo è largo, con margine anteriore rettilineo e pinne cefaliche ben separate tra loro, bocca dritta, ampia e terminale, con denti piccoli; gli occhi e gli spiracoli sono posti lateralmente. Le pinne pettorali sono molto ampie, con apici acuti, mentre le ventrali e la dorsale sono ridotte. La coda è lunga, particolarmente nei giovani, e dotata di breve aculeo caudale. La colorazione del dorso è nera, con riflessi bluastri soprattutto negli esemplari adulti, mentre nei giovani il colore può variare da grigio scuro a nero; spesso è presente una sfumatura più chiara a forma di arco, con la parte concava rivolta in avanti. La parte ventrale è bianca, con chiazzatura nerastra più o meno pronunciata (Tortonese, 1956; Notarbartolo di Sciara & Bianchi, 1998).

La riproduzione è vivipara aplacentata, la durata della gestazione è ignota; alla nascita misura circa 170 cm di larghezza, ed ha un peso di circa 35 kg (Notarbartolo di Sciara & Serena, 1988). Frequenta la zona epipelagica, nutrendosi di organismi planctonici e di piccoli pesci (Bertolini, 1934; Tortonese, 1956).

S'ipotizza che *M. mobular* sia presente in tutto il bacino del Mediterraneo, sebbene le segnalazioni riportate in letteratura siano localizzate quasi totalmente nel bacino Occidentale di questo mare. Catture di *M. mobular* nel Mediterraneo vennero, infatti, riportate in Francia (Risso, 1810; Bougis, 1959; Granier, 1964; Capapé *et al.*, 1990), Italia (nei Mari Tirreno e Ligure) (Doderlein, 1881; Bertolini, 1934; Tortonese, 1956; Boero & Carli, 1979; Notarbartolo di Sciara & Serena, 1988; Vanni, 1992; Di Natale, 1997), Algeria (Guichenot, 1850; Pellegrin, 1901; Dieuzeide *et al.*, 1953; Hemida *et al.*, 2002), Tunisia (Capapé & Zaouali, 1976; Bradaï & Capapé, 2001) e nel bacino Levantino Orientale (Golani, 1996). Notarbartolo di Sciara & Bianchi (1998) hanno suggerito che la specie sia da ritenersi endemica al Mediterraneo, ipotesi che resta tuttavia da verificare, dal momento che la sua presenza è stata sporadicamente segnalata anche nell'Oceano Atlantico orientale (Lozano Rey, 1928; Capapé *et al.*, 1994, 1995).

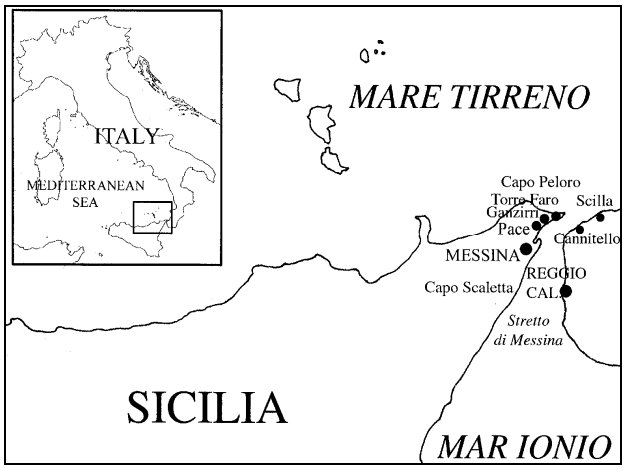

Fig. 1: Cartina dell'area delle catture e degli avvistamenti. (Disegno: A. De Maddalena)
Sl. 1: Zemljevid obravnavanega območja. (Risba: A. De Maddalena)

MATERIALI E METODI

Nel corso di una ricerca condotta al fine di ampliare le conoscenze riguardo alla presenza dei grandi elasmobranchi sia stanziali sia di passaggio nelle acque dello Stretto di Messina, si è avuto modo di raccogliere interessanti dati riguardanti la presenza della mòbula in quest'area. La specie viene da sempre avvistata ed occasionalmente catturata con tutti gli attrezzi utilizzati nella pesca professionale ai grandi animali pelagici (Di Natale, 1997) ed è quindi conosciuta molto bene dai pescatori calabresi e siciliani, dai quali è chiamata dialettalmente *"taddarita"* (nome comunemente riferito al pipistrello e derivante dalla similitudine nelle forme di questi due animali).

Le informazioni, sono state raccolte sia durante alcuni periodi passati sulle imbarcazioni che pescano in quest'area, sia intervistando gli autori di catture ed avvistamenti, riuscendo a raccogliere notizie relative alle dimensioni, al sesso ed agli attrezzi utilizzati nel catturare gli individui. Nella quasi totalità dei casi le informazioni relative agli esemplari riportati in questo lavoro sono avvalorate da fotografie.

Gli esemplari qui trattati, sono stati avvistati o catturati negli anni compresi tra il 1990 ed il 2003, ad eccezione di un individuo pescato nel 1970. Le notizie raccolte si riferiscono a 50 esemplari, e riguardano 5 catture e 45 avvistamenti registrati lungo le due sponde dello Stretto di Messina tra i mesi di Maggio ed Agosto (Fig.1).

RISULTATI

Il primo caso preso in considerazione, poiché provato non solo dalle dichiarazioni del pescatore e dai presenti al momento dello sbarco, ma anche dal riscontro fotografico, si riferisce ad un esemplare catturato nel luglio del 1970, nelle acque antistanti Capo Peloro (ME). L'individuo, una femmina, era largo 200 cm ca., e venne catturato dai pescatori di una barca per la pesca al pesce spada (*Xiphias gladius*), utilizzando un arpone (N. La Fauci, *com. pers.)* (Fig. 2).

Fig. 2: Mòbula catturata nel 1970 (gentilmente concessa da N. La Fauci).
Sl. 2: Ulovljeni primerek morskega vraga iz leta 1970 (z dovoljenjem N. La Fauci).

Dal 1970 fino al 1990 non si hanno notizie di altre catture provate da fotografie, ma dalle informazioni raccolte intervistando i pescatori ed i commercianti di pesce delle due sponde dello Stretto di Messina, emerge che ogni estate veniva catturato qualche esemplare e che nel periodo compreso tra la primavera e l'estate, in queste acque il passaggio di mòbule è sempre stato abbastanza frequente. Tali informazioni, sebbene raccolte intervistando testimoni ritenuti attendibili, non sono state incluse nel presente lavoro poiché non sono stati ritrovati reperti (foto e/o parti di animali) che potessero avvalorare il dato.

Le informazioni relative agli anni compresi fra il 1970 ed il 1990, vengono riconfermate dal 1990 in poi, poiché nelle imbarcazioni che pescano in queste acque si ha la costante presenza di biologi marini che lavorano a progetti di ricerca sui grandi pelagici, dunque i dati raccolti sulla mòbula risultano essere attendibili, dettagliati e spesso provati da materiale fotografico. Qui di seguito vengono riportati i casi considerati.

All'alba del 14. 7. 1990, nel tratto di mare compreso tra Bagnara calabra e Scilla (RC), un grosso esemplare femmina, largo 300 cm ca., rimase ammagliato a circa 4 m dalla superficie, in una rete derivante, chiamata "mutulara" utilizzata per catturare tombarelli *(Auxis rochei),* e palamite *(Sarda sarda).* Il grosso individuo fu ritrovato ancora in vita ed i pescatori lo uccisero colpendolo con un bastone (G. Seminara, *com. pers.)* (Fig. 3).

Il 16. 7. 1991, i pescatori del motopeschereccio "Rocco padre", erano impegnati a recuperare la spadara (rete derivante utilizzata per catturare il pesce spada), al largo della costa di Bagnara Calabra, quando notarono la presenza di un grosso pesce nella rete. Credendo si trattasse di un pesce spada, si affrettarono a tirarlo a

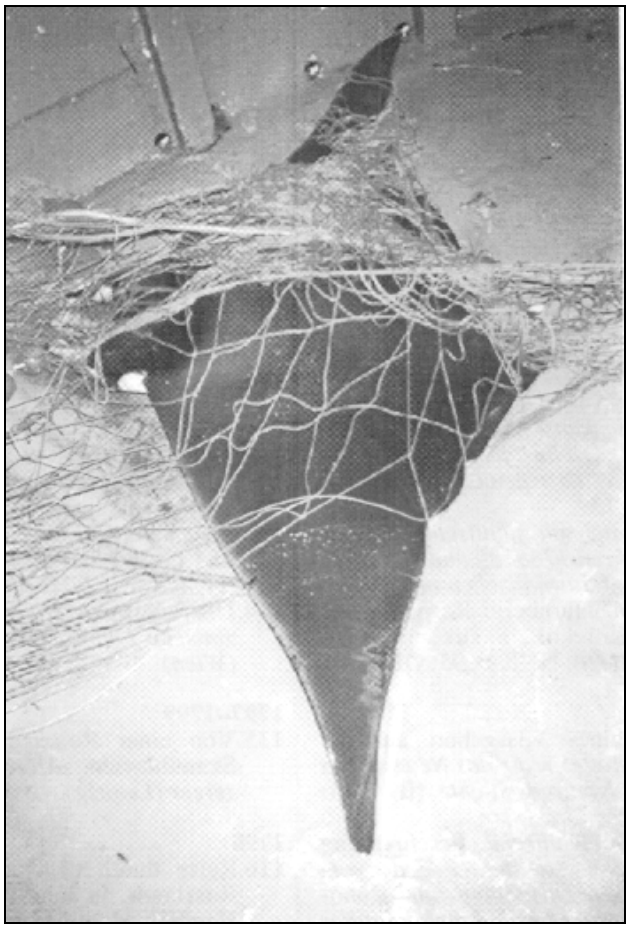

Fig. 3: Mòbula catturata con rete derivante il 14. 7. 1990 (gentilmente concessa da Istituto Aquastudio).
Sl. 3: Ulovljeni primerek morskega vraga z dne 14. 7. 1990 (z dovoljenjem inštituta Aquastudio).

bordo, ma con stupore si resero conto che si trattava di una mòbula. I pescatori hanno dichiarato che pesava 274 kg e che fu venduta in una pescheria di Bagnara (RC) (R. Bagnato, *com. pers*.).

Il 21. 8. 1992, il sig. N. Arena, stava pescando a circa un miglio e mezzo a nord-ovest dalla costa di Torre faro (ME), quando ad un tratto, accanto alla sua piccola imbarcazione vide emergere 3 mòbule. Gli individui nuotarono in prossimità della barca senza mostrare fastidio, rimasero vicini per circa 5 minuti e dopo, lentamente, scomparvero dirigendosi verso il fondo. Gli animali erano larghi 2 m ca. e sotto di essi vi erano diversi esemplari di pesci pilota *(Naucrates ductor)* (N. Arena e G. Salpietro, *com. pers.).*

Il 12. 7. 1998, nelle acque al largo di Ganzirri (ME), il sig. N. Donato si trovava a bordo della sua feluca (caratteristica imbarcazione utilizzata per la pesca del pesce spada nelle acque dello Stretto di Messina) quando fu avvistata una mòbula, che nuotava in prossimità della superficie a circa 350 m dalla costa. Catturato

l'animale, fu constatato trattarsi di una femmina larga 245 cm (N. Donato, *com. pers.)* (Fig. 4).

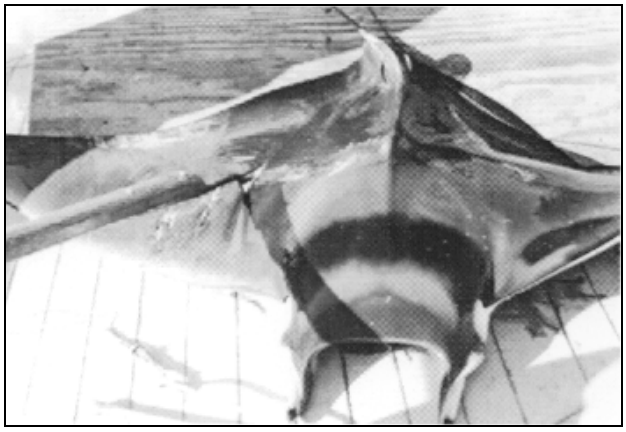

Fig. 4: Mòbula catturata con arpone il 12. 7. 1998 (gentilmente concessa da A. Donato).
Sl. 4: Morski vrag, ulovljen 12. 7. 1998 s harpuno (z dovoljenjem A. Donata).

Il 26. 8. 1998, al largo di Reggio Calabria, un pescatore di pesce spada, mentre si trovava sulla sua barca, avvistò 3 mòbule; le loro dimensioni non superavano i 300 cm ca. Gli animali nuotavano vicinissimi alla superficie in direzione nord e non parvero infastiditi dalla presenza dell'imbarcazione (L. Mancuso, *com. pers.).*

Fig. 5: Mòbula catturata con arpone il 14. 8. 1999 (gentilmente concessa da G. Donato).
Sl. 5: Morski vrag, ulovljen 14. 8. 1999 s harpuno (z dovoljenjem G. Donata).

Il pomeriggio del 14. 8. 1999, nel tratto di mare antistante Pace (ME) durante una battuta di pesca al pesce spada, furono avvistati 6 esemplari di mòbula da N. Donato; uno di questi, una femmina di circa 250 cm, fu catturato (Fig. 5). Nel momento in cui il pescatore scagliò l'arpone, gli altri esemplari fuggirono velocemente verso il fondo, ma quando iniziò il recupero dell'animale colpito gli altri si avvicinarono ad esso come incuriositi. Su tale individuo furono raccolti e conservati alcuni parassiti e lo stomaco, che in seguito fu analizzato.

Il 13. 6. 2000, l'autore si trovava su una feluca, al largo di Capo Peloro, quando all'improvviso un gruppo di 8 mòbule si avvicinò all'imbarcazione. Gli individui nuotavano in superficie, distanti alcuni metri l'uno dall'altro, procedendo lentamente verso nord, e di tanto in tanto si avvicinavano alla prora per poi allontanarsi di qualche decina di metri. L'incontro durò pochi minuti, poi gli animali si immersero repentinamente (Fig. 6).

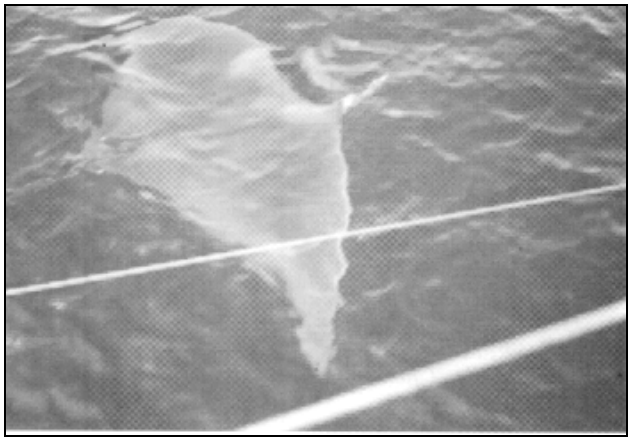

Fig. 6: Mòbula avvistata nello Stretto il 13. 6. 2000 (gentilmente concessa da A. Donato).
Sl. 6: Morski vrag, opažen 13. 6. 2000 v Mesinski ožini (z dovoljenjem A. Donata).

Il 24. 7. 2000 intorno alle ore 13.40, nel tratto di mare antistante Ganzirri (ME), ad una distanza dalla costa di circa 300 m, furono avvistati 7 individui. Gli animali erano intenti a predare probabilmente eufausiacei, e rimasero nella stessa zona per qualche minuto, per poi scomparire improvvisamente all'arrivo di diverse imbarcazioni di diportisti incuriositi.

La mattina del 21. 8. 2001 nella zona antistante Cannitello (RC), ad una distanza di circa 500 m dalla costa, furono avvistati almeno 5 esemplari di mòbula da parte di alcuni pescatori intenti alla pesca del pesce luna *(Mola mola).* Gli individui emersero improvvisamente accanto all'imbarcazione, e rimasero in prossimità di questa per qualche minuto prima di immergersi (G. Scuteri, *com. pers.).*

Il 14. 5. 2002, al largo di Ganzirri, alcuni pescatori impegnati nella pesca delle aguglie *(Belone belone),* per mezzo della rete derivante chiamata "Ugghiara", videro

emergere a poca distanza 3 mòbule. I pescatori hanno dichiarato che gli individui seguirono lentamente il bordo della rete fino ad uscire per poi dirigersi in direzione Nord (P. Mancuso, *com. pers.*).

Il 27. 7. 2002 durante una battuta di pesca al pesce spada, al largo di Scilla (RC), un gruppo composto da circa 6 mòbule emerse in prossimità dell'imbarcazione. Gli animali si avvicinavano alla prora, per allontanarsi repentinamente. In quell'occasione le mòbule erano accompagnate da un grosso branco di stenelle *(Stenella coeruleoalba).* L'incontro durò circa 2 minuti, quando ad un tratto le mòbule iniziarono a nuotare velocemente verso nord, scomparendo quasi subito alla vista.

Il 16. 6. 2003, a circa 4,5 miglia a sud di Reggio Calabria, dei pescatori, che stavano recuperando una rete derivante utilizzata per catturare le alalunghe *(Thunnus alalunga),* videro due grandi esemplari di mòbula a pochi metri dall'imbarcazione. A detta dei testimoni gli animali nuotavano subito sotto la superficie con le pinne cefaliche "srotolate" e con la bocca spalancata, comportamento tipico di questa specie durante l'alimentazione. I pescatori inoltre hanno dichiarato che quel giorno notarono la presenza di banchi di "gamberetti" in superficie; i pescatori di alalunghe chiamano "gamberetto" gli eufausiacei, in particolare *Meganychtiphanes norvegica,* sempre presente in grandi quantità in queste acque, e che per loro rappresenta un segnale della presenza di diverse specie di tunnidi tra cui le ambite alalunghe (A. Forzini, *com. pers.).*

Il 23. 7. 2003, in un tratto di mare al largo di Capo Scaletta (ME) all'imbrunire, un pescatore che si accingeva a calare in acqua il richiamo luminoso per la pesca dei totani *(Todarodes sagittatus)* su di un fondale di circa 600 metri, vide tre grosse mobule passare pochi centimetri sotto la superficie e a circa tre metri dalla propria imbarcazione. Il pescatore dichiarò che gli animali passarono a pochi metri dalla barca senza rallentare (G. Manganaro, *com. pers.).*

DISCUSSIONE

L'area dello Stretto di Messina, sembra essere una zona molto interessante per quanto concerne la presenza della mòbula. Difatti dai dati raccolti emerge che tale specie è presente in queste acque con una certa costanza, soprattutto nel periodo che va dalla tarda primavera all'estate, ed in particolare sembra che prediliga i mesi estivi. Anche se i dati raccolti si riferiscono a catture ed avvistamenti avvenuti nei mesi che vanno da Maggio ad Agosto (Tab. 1), è comunque importante sottolineare che si riferiscono solo a quel periodo probabilmente perché in quei mesi sono presenti nello Stretto le particolari imbarcazioni munite di un alto albero che ne permette l'avvistamento; non si esclude dunque la possibilità che la mòbula attraversi questo importante "gate" migratorio anche in altri periodi dell'anno.

Tab. 1: Catture ed avvistamenti di mòbula (*Mobula mobular****) nello Stretto di Messina. Legenda: arp. = arpone, spad. = rete spadara.***

Tab. 1: Ulovljeni in opaženi primerki morskega vraga (*Mobula mobular****) v Messinski ožini. Legenda: arp. = ulovljen s harpuno, spad. = ulovljen z mrežo za mečarice.***

Anno	Maggio	Giugno	Luglio	Agosto	Avvista-menti	Catture	Totale
1970			1			* arp.	**1**
1990			1			* spad.	**1**
1991			1			* spad.	**1**
1992				3	*		**3**
1998			1	3	*	* arp.	**4**
1999				6	*	* arp.	**6**
2000		8	7		*		**15**
2001				5	*		**5**
2002	3		6		*		**9**
2003		2	3		*		**5**
Totale	*3*	*10*	*20*	*17*	**45**	**5**	**50**

Dalle dichiarazioni rilasciate dai pescatori e raccolte dai biologi marini che si trovavano sulle imbarcazioni al momento degli avvistamenti e delle catture, pare che le mòbule in transito in queste acque nuotino comunemente in gruppi composti in media di 5 o 6 individui, anche se in due casi al momento della cattura l'esemplare non era accompagnato da altri. Le cinque catture descritte nel presente lavoro sono state realizzate in due casi accidentalmente, utilizzando reti derivanti usate nella pesca ai grandi pelagici, e negli altri tre casi con l'ausilio di arponi adottati in questa area nella pesca al pesce spada. Da qualche anno non vengono più catturate mòbule, cosa che un tempo avveniva con una certa frequenza, in quanto le carni di questa specie sono ritenute ottime. Probabilmente sono due le ragioni per le quali non si registrano più catture. La prima è la diminuzione drastica delle reti derivanti, che catturavano accidentalmente molte mòbule durante le stagioni di pesca. La seconda va ricercata nel fatto che i pescatori che praticano la caccia al pesce spada nell'area dello Stretto di Messina hanno cessato di pescare volutamente qualche mòbula all'anno a scopo alimentare come facevano un tempo, e questo grazie ad una maggiore attenzione per la conservazione dell'ecosistema marino.

Durante gli avvistamenti sono stati osservati molto spesso alcuni individui intenti a cacciare organismi planctonici che, nel periodo che va dalla primavera all'estate, formano grossi banchi che stazionano nell'area considerata.

Dall'osservazione del contenuto stomacale di uno degli esemplari pescati, si è notata la presenza di pirosomi non identificati, eufausiacei *M. norvegica,* clupeiformi *Sardinella aurita* e *Maurolicus muelleri* e micto-

fidi *Myctophum punctatum* e *Argyropelecus hemigymnus*, che com'è noto, nello Stretto di Messina sono trasportati in acque superficiali dalla corrente nel momento in cui questa ha direzione sud-nord. L'osservazione, anche se di un solo stomaco, ha dato la possibilità di capire di cosa si nutra la mòbula durante il transito in queste acque. Un passaggio così frequente, si potrebbe spiegare con la presenza di prede molto facili da catturare e soprattutto in grosse quantità, che costituirebbero un rifornimento di energie durante lo spostamento verso nord. Tale considerazione trova riscontro da quanto emerge in Zagami *et al.* (1992), che analizza il contenuto calorico dei pesci mesopelagici più comuni nello Stretto di Messina, e indica valori nutrizionali molto alti per quanto riguarda alcune delle specie rinvenute nello stomaco, in particolare per *A. hemigymnus* e *M. muelleri*. Inoltre, la varietà di prede rinvenute nell'esemplare analizzato lascia ritenere che *M. mobular* sia un predatore opportunista.

Su uno degli esemplari catturati, sono stati trovati e conservati alcuni copepodi parassiti che si trovavano nella parte ventrale, in prossimità dell'apertura cloacale, in seguito diagnosticati come *Echthrogaleus coleoptratus*, è importante rilevare che questo particolare parassita è stato segnalato su altre specie di elasmobranchi, ma mai prima d'ora su mòbula.

Gli esemplari catturati sono risultati essere tutti di sesso femminile, fatto questo che può indurre a pensare che esista una sorta di segregazione sessuale per *M. mobular*, così come avviene per altre specie di elasmobranchi. Non si sono tuttavia registrate catture di individui gravidi.

Si è avuto modo di osservare altre specie nuotare a fianco di gruppi di mòbule. In un caso si è registrata la presenza di una balenottera comune *Balaenoptera physalus*, in altri casi erano presenti alcuni tursiopi *Tursiops truncatus*, stenelle *S. coeruleoalba*, tonni *Thunnus thynnus*, aguglie imperiali *Tetrapturus belone* e pesci pilota *N. ductor*. Su tutti gli individui catturati erano presenti alcuni esemplari di remora *Echeneis naucrates*.

Inoltre, emerge che le mòbule in transito in queste acque, nel periodo compreso tra la tarda primavera e l'inizio dell'autunno, si spostano sempre in direzione nord e mai si è avuto modo di osservare individui transitare in direzioni diverse.

La presenza costante di *M. mobular* in queste acque ha spinto la società di ricerca Necton ad iniziare un monitoraggio di tale specie, allo scopo di approfondire le conoscenze a proposito della sua biologia e delle sue abitudini migratorie. E' previsto che tale progetto divenga operativo dalla primavera del 2005.

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UJETI IN OPAŽENI OSEBKI MORSKEGA VRAGA, *MOBULA MOBULAR* (BONNATERRE, 1788) V VODAH MESSINSKE OŽINE

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POVZETEK

Avtor je zbral podatke o 50 primerkih morskega vraga (5 ujetih in 45 opaženih) v Messinski ožini v obdobju med letoma 1990 in 2003 (z izjemo enega primera iz leta 1970). Podatki kažejo, da se morski vrag redno pojavlja na obravnavanem območju, še posebej v kasni pomladi in poleti (maj-avgust), ko se skupine 5 do 6 osebkov selijo proti

severu. Avtor je pregledal želodec enega od ujetih osebkov in v njem našel svetleče kozice (Euphausiacea) ter ostanke rib Sardinella aurita, Maurolicus muelleri, Myctophum punctatum *in* Argyropelecus hemigymnus. *Vsi ulovljeni osebki so bile samice, kar morda kaže na spolno ločene skupine morskih vragov.*

V nekaterih primerih so morski vragi plavali skupaj z drugimi vrstami velikih nektonskih živali, kot so npr. brazdasti kit (Balaenoptera physalus), *velike pliskavke* (Tursiops truncatus), *progasti delfini* (Stennella coeruleoalba), *tuni* (Thunnus thynnus), *jadrovnice* (Tetrapturus belone) *in ribe piloti* (Naucrates ductor). *Na vseh ujetih primerkih morskih vragov je bilo nekaj prilepov* Echeneis naucrates.

V zadnjih letih ribiči niso ulovili nobenega morskega vraga, po avtorjevi domnevi zaradi drastičnega zmanjšanja števila primernih mrež in tudi večje ozaveščenosti ribičev za varovanje morskega ekosistema.

Ključne besede: morski vrag, *Mobula mobular*, ribolov, vedenje, prehranjevanje, Sredozemsko morje

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THE ELASMOBRANCH SPECIES FROM THE BAHIRET EL BIBAN (SOUTHERN TUNISIA, CENTRAL MEDITERRANEAN): A SURVEY

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ABSTRACT

Ten elasmobranch species have been recorded in the Bahiret el Biban, a hyperhaline brackish area located in southeastern Tunisia and adjoined to the Gulf of Gabes. Five of them, which permanently inhabit the lagoon, are paralic species: Raja miraletus, R. radula, Rhinobatos rhinobatos, R. cemiculus *and* Dasyatis chrysonota. *Permanent occurrence of the regular migratory species* Scyliorhinus canicula *and* Torpedo torpedo *requires further confirmation. Other records are probably due to fortuitous events. They concern* Prionace glauca, Sphryrna zygaena *and* Raja clavata, *which are strictly thalassic species.*

Key words: Elasmobranchs, distribution, reproductive biology, Bahiret El Biban, Tunisia, Mediterranean Sea

SPECIE DI ELASMOBRANCHI A BAHIRET EL BIBAN (TUNISIA MERIDIONALE, MEDITERRANEO CENTRALE): INDAGINE

SINTESI

L'articolo presenta dieci specie di elasmobranchi ritrovate a Bahiret el Biban, area salmastra iperalina situata nella Tunisia meridionale e confinante con il Golfo di Gabes. Cinque di queste specie abitano nella laguna in modo permanente: Raja miraletus, R. radula, Rhinobatos rhinobatos, R. cemiculus *e* Dasyatis chrysonota. *La presenza permanente di* Scyliorhinus canicula *e* Torpedo torpedo *richiede ulteriori conferme. Gli altri avvistamenti nell'area vanno probabilmente attribuiti ad eventi fortuiti.*

Parole chiave: Elasmobranchi, distribuzione, biologia di riproduzione, Bahiret el Biban, Tunisia, mare Mediterraneo

INTRODUCTION

According to Compagno & Cook (1995), 43 elasmobranch species "occur in fresh waters far beyond the tidal reaches of river mouths". They further state that "these occur in tropical and warm-temperate rivers and lakes and adjacent inshore marine waters or are confined to brackish or fresh waters".

Schwartz (1995) recorded 22 elasmobranch species occurrences "from low saline waters of north Carolina". The author states that dasyatids, such as the Atlantic stingray, *Dasyatis sabina* (Lesueur, 1824) and the bluntnose stingray, *D. sayi* (Lesueur, 1817), frequent lower saline to freshwater during the summer.

To our knowledge, freshwater elasmobranchs have not been recorded in the rivers and/or lakes of the Mediterranean countries. However, in Algeria, Dieuzeide *et al.* (1953) reported that some species of the genus *Dasyatis* entered freshwater of coastal rivers at the time of parturition. In Tunisia, we observed numerous pregnant females of common stingray, *D. pastinaca* (Linnaeus, 1758) carrying near-term embryos, which were captured by gill nets in the estuary of the River Miliane, 15 km south Tunis. These observations are probably due to the fact that female elasmobranch species move close to the coastal shore to lay eggs or to expel their neonates. They migrate into specific places called nurseries, where young specimens can find sufficient food to develop and avoid intraspecific and/or interspecific competition pressure and cannibalism (Muñoz-Chapuli, 1984; Castro, 1993; Compagno & Cook, 1995; Schwartz, 1995). The faunistic lists concerning Mediterranean lagoons rarely report elasmobranch catches in these areas. These captures are generally considered to be occasional by Paris & Quignard (1971) and Quignard & Zaouali (1980, 1981). Some species are generally found in lagoons as a result to unfavourable weather conditions. Sometimes, they are thrown into the lagoons by fishermen when they land elasmobranchs caught in close marine areas. Only two species are cited: the smallspotted catshark, *Scyliorhinus canicula* (Linnaeus, 1758), and the marbled electric ray, *Torpedo marmorata* Risso, 1810.

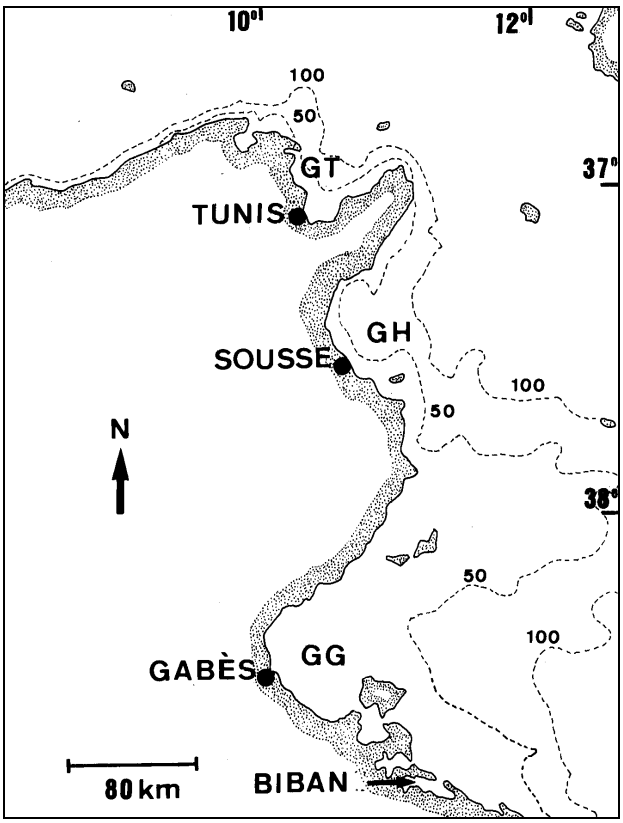

Fig. 1: Map of Tunisia showing the Bahiret el Biban.
Sl. 1: Zemljevid Tunizije z vrisano laguno Bahiret el Biban.

In Tunisia, Zaouali (1977) noted a total absence of elasmobranchs in the Lagoon of Tunis (northern Tunisia). By contrast, Zaouali (1982) reported three elasmobranch species at least in the Bahiret el Biban (southern Tunisia): *Raja* sp., the blackchin guitarfish, *Rhinobatos cemiculus* (Geoffroy Saint-Hilaire, 1817) and the common guitarfish, *R. rhinobatos* (Linnaeus, 1758). Further investigations conducted in this area, and observations made at Tunis fishmarket, along with information provided by fishermen allow us to complete these previous papers and to conclude that a larger number of elasmobranch species occur in the Bahiret el Biban than has previously been reported.

MATERIAL AND METHODS

The Bahiret el Biban is located in southeastern Tunisia and adjoins the Gulf of Gabes (Fig. 1). It appears as an elongated ellipse with its major axis directed WNW-ESE (Fig. 2). Its surface area covers 230 km^2 approximately. Its volume reaches 0.81 km^3 at low tide. Its maximum depth exceeds 6 m in the middle part of the basin (Medhioub & Perthuisot, 1977; Denizot *et al.*, 1981; Guélorget *et al.*, 1982; Medhioub *et al.*, 1986; Perthuisot & Guélorget, 1987).

A narrow belt of 35-km long land remains between the Gulf of Gabes and the Bahiret el Biban (Fig. 2). This belt is broken in its mid-part and forms the islets of El Biban and two "slobs" (slope in Arabic); to the east the "slob ech chergui" and to the west the "slob el gharbi". The two "slobs" are not offshore bars but Tyrrhenian sand hills today partially sunken. Between the "slob ech chergui" and the "slob el gharbi", a fish trap was built (Fig. 3).

Much of the material we examined was collected from 1980 to 1990 at the fishmarket of Tunis. This material was not included among fishes caught in the close fishing areas. It was always and strictly labelled as

"specimens fished in the Bahiret el Biban". So, their origin is considered to be certain. Other observations were made directly at the fish trapping built in the Bahiret el Biban. Fishermen of the lagoon also provided interesting information on elasmobranch species that inhabit and/or have been recorded in the lagoon.

Sharks, rhinobatids and the common torpedo were measured to the nearest millimetre in terms of total length (TL), skates and the blue stingray in terms of disk-width (DW).

The reproductive stages followed Bass *et al.* (1973). Males were considered to be adult when the claspers were elongated, rigid and calicified. By contrast, the claspers of juveniles are short and flexible. Females were considered to be adult when at least yellow yolked or ripe oocytes ready to be ovulated were present in the ovaries and the genital duct was fully developed.

Recognizable prey items from stomach content were generally identified to zoological group and family.

The species recorded in the Bahiret el Biban were separated into three categories following Guélorget & Perthuisot (1983, 1992).

The first category includes sedentary species of small size that were abundantly and regularly caught all year round in lagoons. They develop and reproduce only in confined area. They are strictly paralic species.

The second category comprises species that generally reach a larger size and occasionally enter lagoons as a consequence of fortuitous events such as a strong tide, or discarded alive by fishermen after landings, or turned out accidentally from migratory movements. They develop and reproduce only in offshore areas. They are strictly thalassic species.

The third category concerns species of which fry and juveniles (0+) enter lagoons in order to find sufficient resources to develop and/or to reproduce during a period of their life, and consequently lagoons may be considered as trophic, reproductive or nursery areas. These species constitute a mid-term between thalassic and paralic species, they are "mixed species" or rather regular migratory species.

Furthermore, Guélorget & Perthuisot (1983, 1992) included both thalassic and regular migratory species in a supra category (named thalassoid species), which comprises all species born in sea in both inshore and offshore waters.

RESULTS

Family Scyliorhinidae
Smallspotted catshark, *Scyliorhinus canicula* (Linnaeus, 1758)

This small shark is considered to be very common and abundant off the Tunisian coast and especially in the Gulf of Gabes (Capapé, 1977).

This author noted that in these areas males reached sexual maturity at 400 mm TL and females between 400 mm and 450 mm TL. Vitellogenetic activity and reproduction occurred all the year round.

At Tunis fishmarket, we found several specimens included in many other elasmobranch species, mainly dasyatids and rhinobatids, fished in the Bahiret el Biban. All were adult. Among them, 56 females and 44 males were measured. Size of females ranged from 450 mm to 500 mm TL; 24 specimens had encapsulated eggs in their genital tract. Size of males ranged from 440 mm to 460 mm TL.

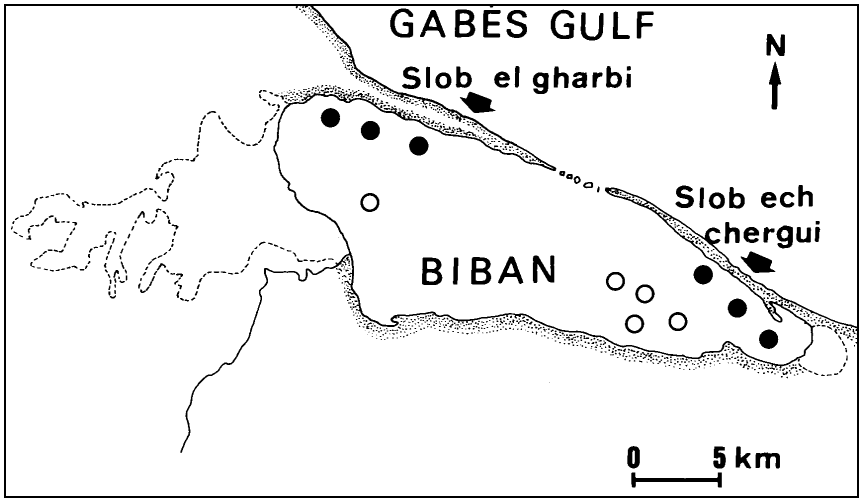

Fig. 2: Map of the Bahiret el Biban (redrawn from Guélorget** et al.**, 1982) showing the places generally inhabited by** Rhinobatos cemiculus **(black circles) and** R. rhinobatos **(circles).
Sl. 2: Zemljevid lagune Bahiret el Biban (prerisano po Guélorget** et al.**, 1982) z lokacijami, ki jih naseljujejo vrste** Rhinobatos cemiculus **(črni krogi) in** R. rhinobatos **(krogi).

Some egg capsules were found in the lagoon. All were empty. Fishermen from the Bahiret el Biban informed us that numerous smallspotted catsharks had been caught after a strong tide occurring in the adjacent marine areas.

Capapé (1974a) showed that specimens from northern Tunisian areas are active predators that feed on cephalopods and teleosts and also on benthic invertebrates, chiefly crustaceans. The stomachs of all the specimens from the Bahiret el Biban contained remains of food, generally unidentified crustaceans and bony fishes.

A permanent presence of the species in the Bahiret el Biban remains questionable and further research is therefore required in order to confirm this presence.

Family Carcharhinidae
Blue shark, *Prionace glauca* (Linnaeus, 1758)

Prionace glauca is common off the Tunisian coasts and in the Gulf of Gabes, where it is captured by gill nets and by anglers (Quignard & Capapé, 1971; Bradaï, 2000).

A juvenile male, 790 mm TL, was captured when about to leave the lagoon. Its stomach content consisted important number of unidentified fishes.

According to Tortonese (1956), size at birth reaches 500–600 mm for specimens from the Mediterranean Sea. Stevens (1974) and Cadenat & Blache (1981) reported 450 mm; Compagno (1984) noted that size at birth ranges from 350 mm to 440 mm TL. Cailliet & Bedford (1983) indicated that "neonates nearly double in length in their first year". The male we have observed was certainly no more than a year old and was probably born in Tunisian marine areas, which could be considered as a possible nursery area for the blue sharks. This opinion was confirmed by records of neonates and near-term females in the Gulf of Gabes (Bradaï *et al.*, *in press).* The specimen caught in the Bahiret el Biban was small, this allowed it to take refuge through the passes. Moreover, since 1996, Hemida & Capapé (2003) reported a significant increase in blue shark captures along the Algerian shore, where the species was formerly considered as rare (see Dieuzeide *et al.*, 1953). Migration of blue sharks eastward and southward in the Tunisian waters could not be neglected as this was the case of other large migratory shark species (Capapé *et al.*, 2003; Capapé *et al.*, *in press).*

Furthermore, this was the first time that the blue shark was recorded in the lagoon. Fishermen informed us that "blue sharks of small size" were sometimes caught in the lagoon. However, this information could be subject to misidentification with other related species, such as carcharhinids, which are abundant in the close marine areas (Capapé, 1989; Bradaï, 2000; Capapé *et al.*, 2003; Bradaï *et al.*, *in press*; Capapé *et al.*, *in press)* and could accidentally invade the Bahiret el Biban.

Family Sphyrnidae
Smooth hammerhead, *Sphyrna zygaena* (Linnaeus, 1758)

The smooth hammerhead has been recorded off the Tunisian coast (Quignard & Capapé, 1971; Capapé, 1989).

A male 600 mm TL was captured in May 1980 through the passes of the lagoon. This specimen exhibited a conspicuous umbilical scar and residual internal vitellin vesicle (IVV), suggesting it was born that year. According to Bigelow & Schroeder (1948), Tortonese (1956) and Compagno (1984), *Sphyrna zygaena* size at birth ranged between 500 and 610 mm TL.

Between 1980 and 1990, six specimens were observed (four males and two females), at the fishmarket of Tunis, ranging from 580 mm to 1200 mm TL. These specimens were probably captured accidentally, when taking refuge in the Bahiret el Biban.

The stomachs of two specimens were empty. Those of the remaining four contained unidentifiable remains of crustaceans and teleosts.

Family Rhinobatidae
Common guitarfish, *Rhinobatos rhinobatos* (Linnaeus, 1758)

According to Quignard & Capapé (1971), the common guitarfish is normally fished in all Tunisian waters, although it is considered more abundant in the south-eastern areas, such as the Gulf of Gabes and the Bahiret el Biban.

Zaouali (1982) considered the captures of the common guitarfish to be relatively less abundant than those of its congeneric species, *R. cemiculus*. Some aspects of the reproductive biology of the common guitarfish were partially described from specimens caught in this lagoon (Capapé *et al.*, 1997). Sizes during first sexual maturity were 750 and 850 mm TL for males and females, respectively, and the maximum size of males and females were 1400 mm and 1620 mm TL, respectively. Pregnant females with encapsulated eggs and embryos at different stages of development, but chiefly with fully developed foetuses were found in the lagoon. The smallest observed gravid female was 860 mm TL. Numerous small free-living specimens with residual IVV were found in the lagoon. Their sizes ranged from 290 mm to 400 mm. The average size of fully developed embryos was 289.9 mm. This suggests that *R. rhinobatos* normally lives and reproduces in this brackish area. An embryonic diapause was suspected because the eggs did not develop during unfavourable season. Their development is probably delayed. Similar patterns were described by Lessa (1982) for the Brazilian guitarfish, *Rhinobatos horkelii*, which inhabits brackish waters of Southern America. Moreover, in *R. rhinobatos* from the Bahiret el Biban, a litter per year remains a probable hypothesis.

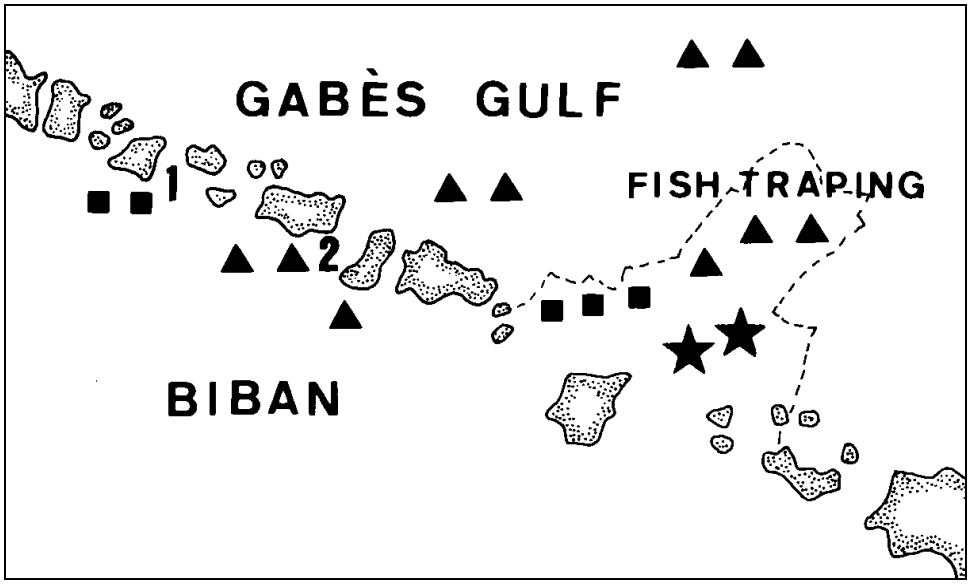

Fig. 3: Detail of the islets (redrawn from Medhioub & Perthuisot, 1977) showing the places where elasmobranch species were caught: *Dasyatis chrysonota* ***(black triangles),*** *Raja miraletus* ***(black stars),*** *Torpedo torpedo* ***(black squares). Numbers 1 and 2 show the passes where*** *T. torpedo* ***and shark species such as*** *Prionace glauca* ***and*** *Sphyrna zygaena* ***were captured.***
Sl. 3: Detajl otočkov (prerisano po Medhioub & Perthuisot, 1977) z lokacijami, kjer so bile ujete naslednje vrste iz podrazreda Elasmobranchii: *Dasyatis chrysonota* ***(črni trikotniki),*** *Raja miraletus* ***(črne zvezde),*** *Torpedo torpedo* ***(črni kvadrati). Št. 1 and 2 ponazarjata prehoda, kjer so bili ujeti*** *T. torpedo* ***in morski psi (kot npr.*** *Prionace glauca* ***in*** *Sphyrna zygaena****).***

Observations on feeding habits showed that all year round, *R. rhinobatos* fed on benthic invertebrates, bony fishes and occasionally, cephalopods. There are no quantitative and/or qualitative seasonal changes in the diet of the common guitarfish by sex and condition, among juveniles and adults (Capapé & Zaouali, 1979).

Blackchin guitarfish, *Rhinobatos cemiculus* (Geoffroy Saint-Hilaire, 1817)

R. cemiculus and *R. rhinobatos* are two sympatric species. They virtually inhabit the same areas in Tunisian waters (Quignard & Capapé, 1971).

Aspects of *R. cemiculus* reproductive biology were also described from specimens collected in the Bahiret el Biban (Capapé & Zaouali, 1994). Sizes during first sexual maturity of males and of females were 1000 mm and 1100 mm TL, respectively. Adult females are generally larger than males, maximal TL for males and females are 1920 mm and 2300 mm, respectively. The smallest gravid female observed was 1220 mm TL. All the year round, pregnant *R. cemiculus* were found in the Bahiret el Biban. Newborn specimens with IVV (mean TL = 323.6 mm) and small free-swimming specimens (400 mm < TL < 500 mm) with obvious umbilical scar on ventral face are regularly found in the lagoon. Ovulation and parturition occur during the winter and the summer, respectively. A litter per year is a probable hypothesis. On the opposite, no embryonic diapause was clearly observed in this species.

Diet and feeding habits of both *R. cemiculus* and of *R. rhinobatos* are similar. Capapé & Zaouali (1979) found benthic invertebrates and bony fishes in stomach contents of the common guitarfish. The species fed all year round and did not exhibit seasonal changes between males and females as well as between juveniles and adults.

Family Torpedinidae
Common torpedo, *Torpedo torpedo* (Linnaeus, 1758)

The common torpedo must be considered an Atlanto-Mediterranean species (see Quignard, 1978, 1979; Quignard & Tomasini, 2000), rather common in Tunisian waters (Quignard & Capapé, 1971; Capapé, 1989). It is mainly caught off the northern coast, in the Gulf of Tunis and in the Gulf of Gabes. It enters the lagoons where it is able to live and reproduce. This abundance allowed us to study some aspects of the reproductive biology of the species (Quignard & Capapé, 1974) and its morphology (Capapé & Desoutter, 1981; Ben Brahim & Capapé, 1997; Ben Brahim *et al.*, 1998).

Torpedo torpedo is abundantly captured in the Ba-

hiret el Biban. However, it seems that specimens do not occur too far inside the lagoon. According to the fishermen, most are caught near the passes and fish traps. Captures of common torpedoes are seasonal. In winter, they enter the lagoon to take refuge, and in summer probably in order to breed. Several gravid females caught during the latter season contained fully developed embryos in the uteri.

Sexual maturity occurs at similar sizes in specimens caught in the Bahiret el Biban and in the Gulf of Tunis (Quignard & Capapé, 1974). All the males and females are adults when they are above 190 mm and 230 mm TL, respectively. However, in the close Gulf of Gabès, Ennajar *et al.* (2002) noted that both males and females were adult above 230 mm TL. In the Gulf of Tunis, Quignard & Capapé (1974) noted that females are larger than males. This was also the case for the Gulf of Gabès (Ennajar *et al.,* 2002). In the first area, maximum sizes for males and females are 390 mm and 410 mm TL, respectively, and in the second, 365 and 410 mm TL, respectively. Capapé & Desoutter (1981) emphasised that large females (> 400 mm TL) are relatively more abundant than males. The specimens captured in the Bahiret el Biban seem to be smaller than those of the Gulf of Tunis and Gulf of Gabès. The largest male and the largest female observed in this lagoon were 330 mm and 350 mm TL, respectively.

A total of 52 stomach contents were examined; all were empty.

Family Rajidae
Thornback ray, *Raja clavata* Linneaus, 1758

Raja clavata is regularly caught off the Tunisian coasts and mainly in the Gulf of Tunis and Gulf of Gabes, where large quantities are caught by trawlers (Capapé, 1976a; Bradaï, 2000).

Fishermen informed us that small thornback rays were rarely found in the Bahiret el Biban. We have observed a single specimen from this lagoon. It was an adult male having 480 mm DW. Its stomach was empty.

This capture was probably accidental, since this skate does not inhabit the lagoon, although it is relatively common in the Gulf of Gabes (Quignard & Capapé, 1971; Bradaï, 2000).

Brown ray, *Raja miraletus* Linnaeus, 1758

The brown ray is rather common in the Tunisian marine areas (Capapé & Quignard, 1974). Numerous specimens from the Bahiret el Biban were collected at the fishmarket in Tunis. In all, 227 specimens were observed: 82 juveniles (45 males, 37 females) and 145 adults (66 males, 79 females). No biometrical differences were observed among the specimens from the Bahiret el Biban and those from the Gulf of Tunis (Capapé & Quignard, 1974). Size at sexual maturity occurs at 220 mm and 240 mm DW by males and by females, respectively, in both areas.

Females with ripe oocytes ready to be ovulated in the ovaries, and/or encapsulated eggs in their oviducts were found all year round. Moreover, egg cases containing embryos at different phases of development were regularly found in the Bahiret el Biban according to fishermen. This suggests that the species is able to reproduce in the lagoon.

The diet of specimens from this lagoon is similar to those from the Gulf of Tunis (Capapé, 1976b). *Raja miraletus* feeds on benthic invertebrates (mainly crustaceans and polychets) and some bony fishes. It does not appear to undergo seasonal changes according to sex and sexual condition (juveniles and/or adults).

Rough ray, *Raja radula* Delaroche, 1809

The rough ray is considered to be an endemic Mediterranean species, frequently caught off the Tunisian coast (Capapé, 1987). *Raja radula* and *R. miraletus* are two sympatric species. *R. radula* inhabits and reproduces in the Bahiret el Biban, where it seems to be relatively more abundant than *R. miraletus* according to our observations and information provided by fishermen. Some of the specimens studied were directly observed in the lagoon, but most of them were collected at Tunis fishmarket.

In an earlier article, Capapé (1974b) noted that male and female *R. radula* caught in the Gulf of Tunis attained sexual maturity at 320 mm and 340 mm DW, respectively, and the largest male and female observed were 400 mm and 420 mm DW, respectively.

Several hundred *R. radula* captured in the Bahiret el Biban were observed at Tunis fishmarket. Among them, 126 males and 158 females were measured. Sexual maturity occurred for males and for females at 280 mm and 310 mm DW, respectively. The largest male and female were 340 mm and 360 mm DW, respectively. All the females bore simultaneously ripe oocytes and encapsulated eggs. Fishermen informed us that egg capsules were frequently found in the lagoon.

The feeding habits of the rough ray from the Bahiret el Biban are very similar to those of specimens caught in the Gulf of Tunis (Capapé, 1976b) and to those of the brown ray.

Family Dasyatidae
Blue stingray, *Dasyatis chrysonota* (Smith, 1828)

In the Mediterranean, the blue stingray has been to our knowledge recorded only in southern Tunisia, especially in the shallow coastal waters of the Gulf of Gabes, in the Bahiret el Biban (Capapé, 1989) and off the coast

of Israel (Golani & Capapé, 2004). Aspects of the reproductive biology of the blue stingray were previously reported by Capapé & Zaouali (1995). These authors noted that size at sexual maturity for males and females is reached at about 300 mm and 320 mm DW, respectively. The largest male and the largest female observed were 400 mm and 440 mm DW, respectively. Estimated size at birth is 118 mm DW. Gestation period lasts for about three months. The relative abundance of juveniles of both sexes and of females at the end of gestation in the Bahiret el Biban and of adults of both sexes in the Gulf of Gabes provides suggestions about *Dasyatis chrysonota* genesic movements through Tunisian waters. Females enter the lagoon to expel near-term embryos, which leave as adults to return into the Gulf of Gabes. Mating, fertilization of ripe oocytes and the greater part of embryonic development probably occur in this latter area. Records of juveniles outside the Bahiret el Biban are of accidental significance.

D. chrysonota is voracious and feeds all year round. The young feed mainly on benthic invertebrates, adults mainly on teleosts (Capapé & Zaouali, 1992).

DISCUSSION

Eighty-six elasmobranch species have been recorded in the Mediterranean (Capapé, 1989; Bradaï *et al.*, *in press)* and 60 in Tunisian waters (Capapé, 1987; Bradaï *et al.*, *in press).* Of the forty-one species reported in southern Tunisian waters (Bradaï, 2000; Bradaï *et al.*, *in press*), ten have been recorded in the Bahiret el Biban.

Following Guélorget & Perthuisot (1983, 1992), of these ten species, recorded in the lagoon, five are paralic species: *R. miraletus, R. radula, R. rhinobatos, R. cemiculus* and *D. chrysonota*; two are regular migratory species: *S. canicula* and T. *torpedo*; three are thalassic species: *P. glauca, S. zygaena* and *R. clavata*. In all, five thalassoid species *(sensu* Guélorget & Perthuisot, 1983, 1992) were recorded.

According to Medhioub & Perthuisot (1977), Zaouali (1982) and Zaouali & Beaten (1985), the Bahiret el Biban is a nursery for several species of benthic invertebrates and for bony fishes of economic interest, especially mullets, soleids and sparids. The elasmobranch species could find sufficient food in the lagoon. Moreover, the size of each species is different, so the interspecific competition pressure between them is probably reduced to a minimum. The biometrical measurements and reproductive data do not show significant intraspecific variations among the specimens caught in the lagoon and those recorded in other Tunisian marine areas except *R. radula* and *T. torpedo*. Population of this latter species from the Gulf of Tunis and from the Bahiret el Biban and other Tunisian areas may be different. However, this hypothesis needs to be confirmed.

S. canicula and *T. torpedo* are frequently caught in the Bahiret el Biban. Nevertheless, their captures only occur in winter during strong tides, and in spring and/or summer, probably to breed. This second aspect chiefly concerns the common torpedo.

The other inside records may be attributed to fortuitous event. Small specimens of *P. glauca* and *S. zygaena* probably lose their way. The occurrence of *R. clavata* in the lagoon was consequently due to a strong tide.

Nevertheless, the number of species recorded in the Bahiret el Biban is not very high and most of the species observed were batoids.

Some factors may account for these characteristics. First, the waters of the Bahiret el Biban are hyperhaline (41–45 ‰). They could reach 52 ‰ during the dry season (summer) in the eastern side of the lagoon (Medhioub & Perthuisot, 1977; Medhioub *et al.*, 1986). Salinity increases with the distance of the passes, which could explain why the common torpedo does not enter too far inside the lagoon.

Second, outside the Bahiret el Biban, the bottom slowly slopes down and 5 m depth is reached 4–5 km off the slobs (Medhioub & Perthuisot, 1977). This topography suggests that the lagoon is a habitat suitable only for batoids and small sharks.

Third, a fish trap was built between the slobs and partially blocked the free access to fishes in the Bahiret el Biban (Medhioub & Perthuisot, 1977; Denizot *et al.*, 1981; Guélorget *et al.*, 1982; Medhioub *et al.*, 1986; Perthuisot & Guélorget, 1987). Figure 3 globally shows the difficulties for elasmobranchs to reach the lagoon through the passes.

These factors could partially explain the rarity of inside records of sharks, skates and rays in the Bahiret el Biban, although its waters are frequently sampled year round.

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PREGLED POJAVLJANJA MORSKIH PSOV IN SKATOV (ELASMOBRANCHII) V LAGUNI BAHIRET EL BIBAN V JUŽNIH TUNIZIJSKIH VODAH

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POVZETEK

V laguni Bahiret el Biban ob Gabeškem zalivu v južnih tunizijskih vodah se pojavlja deset vrst iz podrazreda morskih psov in skatov (Elasmobranchii). Pet izmed njih, ki stalno naseljujejo to morsko območje z rahlo primesjo sladke vode, sodi med evhaline vrste: Raja miraletus, R. radula, Rhinobatos rhinobatos, R. cemiculus *in* Dasyatis chrysonota. *Stalno pojavljanje rednih selečih se vrst* Scyliorhinus canicula *in* Torpedo torpedo *pa terja še dodatno potrditev. Podatki o pojavljanju drugih vrst so bržkone posledica golih naključij, saj gre za vrste* Prionace glauca, Sphryrna zygaena *in* Raja clavata*, ki so izključno morske.*

Key words: Elasmobranchii, razširjenost, reprodukcijska biologija, Bahiret El Biban, Tunizija, Sredozemsko morje

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CETORHINUS MAXIMUS (GUNNERUS, 1765) (LAMNIFORMES, CETORHINIDAE) IN THE GULF OF ANTALYA IN 1987: A SUMMARY OF THE PREVIOUS RECORDS OF THE SPECIES FROM TURKISH COASTAL WATERS IN THE MEDITERRANEAN

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ABSTRACT

A basking shark, Cetorhinus maximus *(Gunnerus, 1765), was accidentally captured in the Bay of Antalya in 1987 by stationary nets set very close to the shore. With the capture of this 4 m long specimen weighing 800 kg, the number of basking sharks recorded in the Mediterranean waters of Turkey rose to 4. Basking sharks are sighted or accidentally captured by fishermen along the southern coast of Turkey in spring and summer. Although it is not yet considered an endangered or threatened species in Turkey, this shark species should be immediately added to the list of protected species. This proposed legal regulation seems necessary in order to protect this vulnerable "k-selected" species from the pressures exerted by coastal fishery.*

Key words: basking shark, *Cetorhinus maximus*, eastern Mediterranean, distribution, coastal occurrence

CETORHINUS MAXIMUS (GUNNERUS, 1765) (LAMNIFORMI, CETORINIDI) NEL GOLFO DI ANTALIA NEL 1987: RIASSUNTO DEI DATI PRECEDENTI RIGUARDANTI LA SPECIE NELLE ACQUE DELLA COSTA TURCA DEL MEDITERRANEO

SINTESI

Nel 1987, in una rete calata nelle immediate vicinanze della riva nel Golfo di Antalia, rimase intrappolato uno squalo elefante Cetorhinus maximus *(Gunnerus, 1765). Con questo esemplare di quattro metri e del peso di ottocento chilogrammi, il numero degli squali elefante individuati nelle acque turche del Mediterraneo è salito a quattro. Nelle acque litoranee della Turchia meridionale, gli squali elefante sono stati osservati o catturati incidentalmente dalle reti dei pescatori soprattutto in primavera ed estate. In Turchia, questo tipo di squalo non è ancora inserito nella lista delle specie minacciate, tuttavia andrebbe compreso senza indugio tra quelle da tutelare; una misura giuridica necessaria soprattutto per proteggere lo squalo elefante dal pericolo della pesca costiera.*

Parole chiave: squalo elefante, *Cetorhinus maximus*, Mediterraneo orientale, diffusione, presenza nelle acque costiere

INTRODUCTION

Basking sharks occur in warm to temperate waters of both Atlantic and Pacific oceans, but are apparently absent in the Indian Ocean (Compagno, 1984). This giant plankton-feeding shark is the largest fish living in the Mediterranean waters (Quero, 1984), and has been credited as reaching a maximum total length of 15.2 m (Compagno, 1984). Its presence in the Mediterranean Sea has been well documented (see for example Risso, 1810; Moreau, 1881; Carus, 1889–1893; Ninni, 1912; Tortonese, 1956; Bini, 1967; Quignard & Capapé, 1971; Papaconstantinou, 1988; Lipej *et al.*, 2000; Cugini & De Maddalena, 2003; Soldo, 2003). However, most of these records are confined to the western parts of this sea. Although the presence of basking shark in Turkish waters has been reported by some researchers (Akyüz, 1957; Akşıray, 1987; Kıdeyş, 1997; Bilecenoğlu *et al.*, 2002; Kabasakal, 2002), the species' distribution and seasonality of occurrence along the Anatolian coast have not been studied in detail. According to Akşıray (1987), basking shark is a very rarely encountered species in Turkish waters.

Accidental capture of a basking shark in stationary nets set very close to shore in the Bay of Antalya in 1987 was revealed during literature search, carried out in order to find out sighted or captured specimens of *Cetorhinus maximus* in Turkish waters. The purpose of the present study is to give information about this accidentally captured specimen, as well as to discuss the distribution and seasonality of *C. maximus*' sightings or captures along the Mediterranean coast of Turkey.

MATERIAL AND METHODS

Information on sightings and captures of basking sharks in Turkish waters was obtained from the following sources: (a) available scientific literature, (b) interviews with fishermen, and (c) popular literature, such as newspapers, fishing magazines, etc. Whenever possible, total length of body, weight, sex and biological condition of the specimen were recorded. Photograph of the specimen captured in the Bay of Antalya is kept in the author's personal archives.

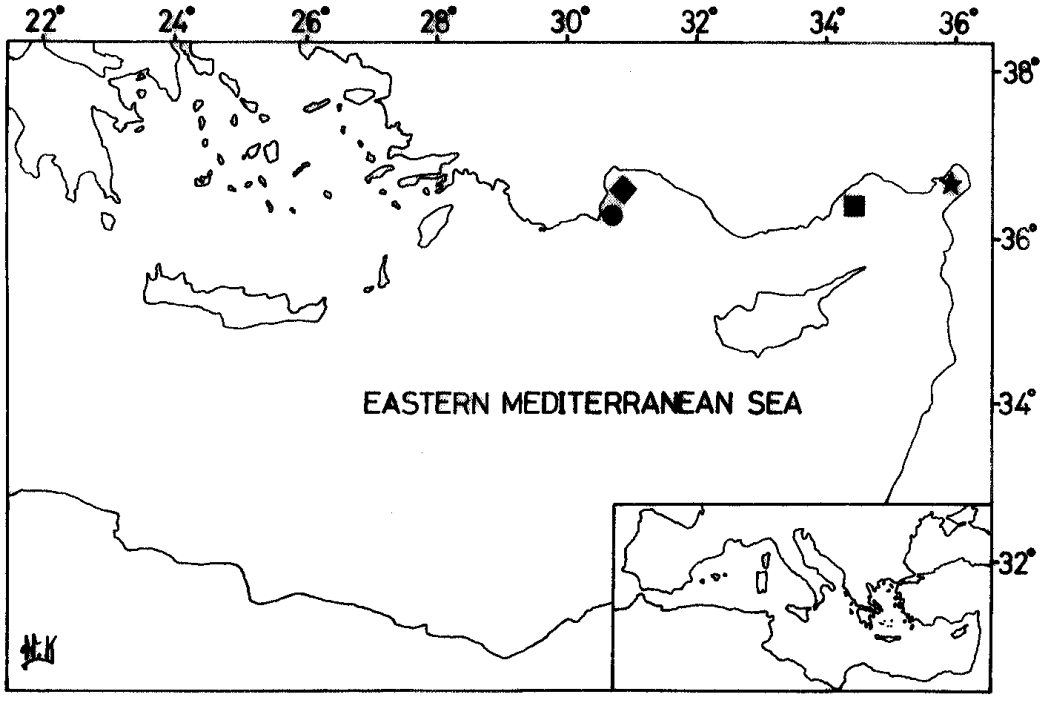

Fig. 1: Map showing the investigated area, with symbols indicating approximate localities, where basking sharks have been captured or sighted along the Mediterranean coast of Turkey: (●) Kemer specimen (TL 4 m), captured on 18 April 1987; (♦) specimen recorded by Kabasakal (2002); (■) specimens recorded by Kıdeyş (1997) and (☆) specimen recorded by Akyüz (1957).

Sl. 1: Zemljevid raziskanega območja s simboli, ki ponazarjajo približne lokalitete v turških obalnih vodah Sredozemlja, kjer so bili ujeti ali opaženi morski psi orjaki: (●) primerek (TL 4 m), ujet 18. aprila 1987 v bližini Kemerja; (♦) primerek, ki ga je zabeležil Kabasakal (2002); (■) primerki, ki jih je zabeležil Kıdeyş (1997) in (☆) primerek, ki ga je zabeležil Akyüz (1957).

RESULTS AND DISCUSSION

Literature search revealed accidental captures of at least 4 basking sharks in the coastal waters of Antalya and Mersin Bay (eastern Mediterranean, Fig. 1) since 1987 (Kıdeyş, 1997; Kabasakal, 2002). Furthermore, small groups of basking sharks (number of individuals not specified) have been sighted by Kıdeyş (1997) in the Bay of Mersin near Erdemli (Fig. 1) in the summer of 1996.

On 18 April 1987, a basking shark has been accidentally captured by stationary nets very close to the shore of Kemer in the Bay of Antalya (A. Savul, *pers. comm.)*. The specimen's total length measured by the fishermen was 4 m, while its weight was nearly 800 kg (Fig. 2). The girth of the specimen was 140 cm. It was pulled on to the beach by a tractor and displayed to the public for a few days.

In December 2001, another basking shark was captured also by means of stationary bonito net, set only 100 m off the shore in the Bay of Antalya (Kabasakal, 2002), and this was the second confirmed record of the species from Turkish waters. Total length of this female (believed to be a sub-adult in view of its size) was 6 m (Kabasakal, 2002). Unfortunately, this basking shark was immediately eviscerated and sold, and therefore no detailed examination could be carried out.

In May 1995, coastal fishermen near Erdemli in the Bay of Mersin captured two basking sharks (Kıdeyş, 1997). One of these basking sharks was 4.7 m long, while sex of the two specimens remains unknown. In August and September of the ensuing year, small schools of basking sharks were sighted in the same area, while feeding on the bloom of ctenophoran *Pleurobrachia pileus* (Kıdeyş, 1997).

Historical records of basking sharks from the Bay of Iskenderun date back to 1950's. Although Iskenderun Bay is a small marine area, some remarkable fishing activities, particularly in terms of mid-water trawling, are carried out here. In the report given by Akyüz (1957), dealing with the environmental characteristics of fishing grounds of *Mullus barbatus* in the Bay of Iskenderun, its author added *C. maximus* to the ichthyological list of the area. However, no recent record of basking shark is available from this bay. On the other hand, as it can be clearly seen in figure 1, the distance between Erdemli coast, from where Kıdeyş (1997) reported on captures or sightings of basking sharks, and Iskenderun Bay is quite short. Regarding the highly migratory behaviour of *C. maximus* (Compagno, 1984), it would not be illogical extending the basking sharks' distribution range to the latter bay.

All of the basking sharks mentioned in the present study have been captured or sighted in coastal waters. With the exception of the specimen captured in December 2001, all individuals were captured or sighted in spring, summer and early autumn (September) (Kıdeyş, 1997; Kabasakal, 2002). According to Francis & Duffy (2002), inshore occurrences of basking sharks reach their peak in spring and summer, while winter sightings are remarkably rare. Seasonality of inshore occurrence of basking sharks reported by Francis & Duffy (2002) coincides with the period of captures or sightings of the specimens along the Turkish Mediterranean coast. The Adriatic Sea is another region, where young basking sharks have been captured or sighted in coastal waters. Lipej *et al*. (2000) recently reported the capture of two juvenile basking sharks by stationary nets set in the coastal waters off Piran. Both specimens were captured between May and July. Capapé *et al*. (2003) reported on the capture of 21 basking sharks off the Maghrebin shore (south Mediterranean Sea) between 1966 and 2002. The authors also reported that all the specimens had been captured in coastal waters by pelagic fishing gear at depths of max. 30 m. According to Capapé *et al*. (2003), among the 21 basking sharks captured off the Maghrebin shore, 12 individuals were caught between March and August, which is yet another indication of coastal occurrence of basking sharks in spring and summer. Sims *et al*. (2000) reported that surface feeding by basking sharks in coastal waters along south-western Britain during spring and summer is closely associated with zooplankton bloom along oceanographic fronts in the area. Similarly, Kıdeyş (1997) reported that basking sharks, sighted in August and September of 1996, were also feeding on the bloom of ctenophorans *P. pileus* near the coast of Erdemli. Kovalev *et al*. (2003) reported that in the coastal regions of the Mediterranean Sea, two to three peaks (spring, summer and autumn) are reached for the zooplankton abundance. According to Kıdeyş (1997), basking sharks also helps eutrophic areas by

Fig. 2: Basking shark captured off the Kemer coast in the Bay of Antalya (TL 4 m). (Photo: A. Savul's archive)
Sl. 2: Morski pes orjak (TL 4 m), ujet v bližini Kemerja v Antalijskem zalivu. (Foto: osebni arhiv A. Savula)

converting surplus organic matter (including gelatinous organisms) into shark flesh, and for this very reason this shark is recommended as one of the most suitable species for the biological control of the voracious predatory ctenophore *Mnemiopsis leidyi*.

To summarise, coastal zooplankton bloom, which occurs in spring, summer and autumn, seems to be an important factor attracting basking sharks to inshore waters (Fig. 3). Seasonality of captures or sightings of basking sharks in the present study is remarkably well correlated with the period of coastal zooplankton bloom, as reported by Kovalev *et al*. (2003). Basking shark is now considered an endangered species in the *IUCN Red List of Threatened Species* (Fowler, 1996). On the other hand, Mediterranean basking sharks are now listed in two important conventions (Annex II – Endangered or Threatened species – of a Protocol of the Barcelona Convention for the Protection of the Mediterranean Sea, and Appendix II of the Bern Convention of European Wildlife and Natural Habitats) (Anonymus, 1998). According to these listings, the species should be given full protection in the Mediterranean. Gill netting is a popular technique of small-scale fishery along the Turkish Mediterranean coast and operated throughout the year. Therefore, coastal fishermen should be informed about the basking shark's status and encouraged to release the entangled specimens. Basking shark should be immediately added to the list of protected species in Turkey, and this proposed legal regulation seems to be necessary in order to protect this vulnerable '*k-selected*' species from the pressure exerted by coastal fishery.

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Fig. 3: Basking shark *(Cetorhinus maximus)* ***grazing at the sea surface in inshore waters. (Photo: B. Šuligoj)***
Sl. 3: Morski pes orjak *(Cetorhinus maximus)* ***se pase na gladini priobalnega morja. (Foto: B. Šuligoj)***

CETORHINUS MAXIMUS (GUNNERUS, 1765) (LAMNIFORMES, CETORHINIDAE) V ANTALIJSKEM ZALIVU LETA 1987: POVZETEK PREJŠNJIH PODATKOV O TEJ VRSTI V TURŠKIH OBREŽNIH VODAH SREDOZEMLJA

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POVZETEK

Leta 1987 se je v mrežo, postavljeno v neposredni bližini kopnega v Antalijskem zalivu, po naključju ujel morski pes orjak Cetorhinus maximus *(Gunnerus, 1765). S tem primerkom, dolgim 4 m in težkim 800 kg, se je število morskih psov orjakov, zabeleženih v turških vodah Sredozemlja, povzpelo na 4. Morski psi orjaki so v turških južnih obrežnih vodah opaženi ali po naključju ujeti v ribiške mreže predvsem spomladi in poleti. Čeprav ta morski pes v Turčiji še ni na seznamu ogroženih vrst, bi ga morali nemudoma vpisati v seznam zaščitenih vrst. Takšno predlagano pravno določilo se zdi potrebno predvsem zato, da bi morskega psa orjaka kot ranljivo vrsto zaščitili pred pritiski razširjenega obalnega ribištva.*

Ključne besede: morski pes orjak, *Cetorhinus maximus*, vzhodno Sredozemlje, razširjenost, pojavljanje v obrežnih vodah

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TWO LARGE SHORTFIN MAKOS, *ISURUS OXYRINCHUS*, RAFINESQUE, 1809, CAUGHT OFF SICILY, WESTERN IONIAN SEA

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ABSTRACT

The authors report on two large shortfin makos Isurus oxyrinchus *captured off Sicily, Western Ionian Sea (Central Mediterranean Sea). A female shortfin mako was caught on 26 July 2003 off Scaletta Zanclea. The specimen's total length of 390 cm was estimated on the basis of a photograph and measurements of the pectoral and first dorsal fins. Another 370-cm female shortfin mako was captured between Portopalo di Capo Passero and Marzamemi and transported to the fish market in Milan, Italy, on 22 June 2004. The two specimens reported in this work are the largest ever recorded in Sicilian waters, and among the largest recorded from the entire Mediterranean Sea.*

Key words: shortfin mako, *Isurus oxyrinchus*, size, Mediterranean Sea

DUE GRANDI SQUALI MAKO DALLE PINNE CORTE, *ISURUS OXYRINCHUS*, RAFINESQUE, 1809, CATTURATI IN SICILIA, MARE IONIO OCCIDENTALE

SINTESI

Vengono segnalati due grandi squali mako dalle pinne corte Isurus oxyrinchus *catturati in acque siciliane, Mare Ionio Occidentale (Mare Mediterraneo Centrale). Il primo, una femmina, venne catturato nel Luglio 2003 al largo di Scaletta Zanclea. La lunghezza totale di questo esemplare è stata stimata pari a circa 390 cm sulla base di una fotografia e delle misure delle pinne pettorali e prima dorsale. Un altro mako dalle pinne corte, di 370 cm di lunghezza, venne catturato tra Portopalo di Capo Passero e Marzamemi e portato al Mercato Ittico di Milano, Italia, il 22 Giugno 2004. I due esemplari qui riportati sono i più grandi mai catturati nelle acque della Sicilia e tra i maggiori registrati sino ad oggi nell'intero Mare Mediterraneo.*

Parole chiave: squalo mako dalle pinne corte, *Isurus oxyrinchus*, dimensioni, Mare Mediterraneo

INTRODUCTION

As in most shark species, female shortfin makos, *Isurus oxyrinchus*, Rafinesque, 1809 (Order Lamniformes, family Lamnidae), reach larger sizes than males. The average total length is 171 cm, based on a recent study of 199 specimens bearing a total length ranging from 70 and 368 cm (Kohler *et al.*, 1996). The maximum length is 445 cm: a huge specimen of this size was caught off Six-Fours les-Plages, France, in September 1973 (Capapé, 1977). Other large specimens have been recorded in the Mediterranean area. A large 425-cm shortfin mako was caught off La Galite Island, Tunisia, on September 24, 1876, with its jaws preserved in the Natural History Museum of Genoa, Italy (Doria & Gestro, 1877). Lawley (1881) reports on a 4 m long and 1,000 kg heavy specimen observed in a warehouse of a fishmonger in Livorno, Italy; it was caught off Piombino, Italy, but the author does not indicate the time of the event and the specimen's weight and measurements seem, unfortunately, to be only approximate as well. A 400-cm shortfin mako captured off Caska, Novalja, Croatia, on May 13, 1882, was reported by Brusina (1888). A 390-cm long shortfin mako was caught on November 30, 1991, off Bagnara Calabra, Italy (Storai *et al.*, 2001). Another 390-cm specimen, weighing 513 kg, was caught on September 20, 2000 off Punta Alice, Italy (Storai *et al.*, 2001).

The shortfin mako's distribution includes the Mediterranean Sea, the Atlantic, and the Indian and Pacific Oceans (Garrick, 1967). Its presence in Sicilian waters is well known (Spallanzani, 1793; Rafinesque, 1809; Tortonese, 1956; Celona *et al.*, 2001; De Maddalena *et al.*, *in press*). Here, we report on two recent records of large shortfin makos from Sicilian waters.

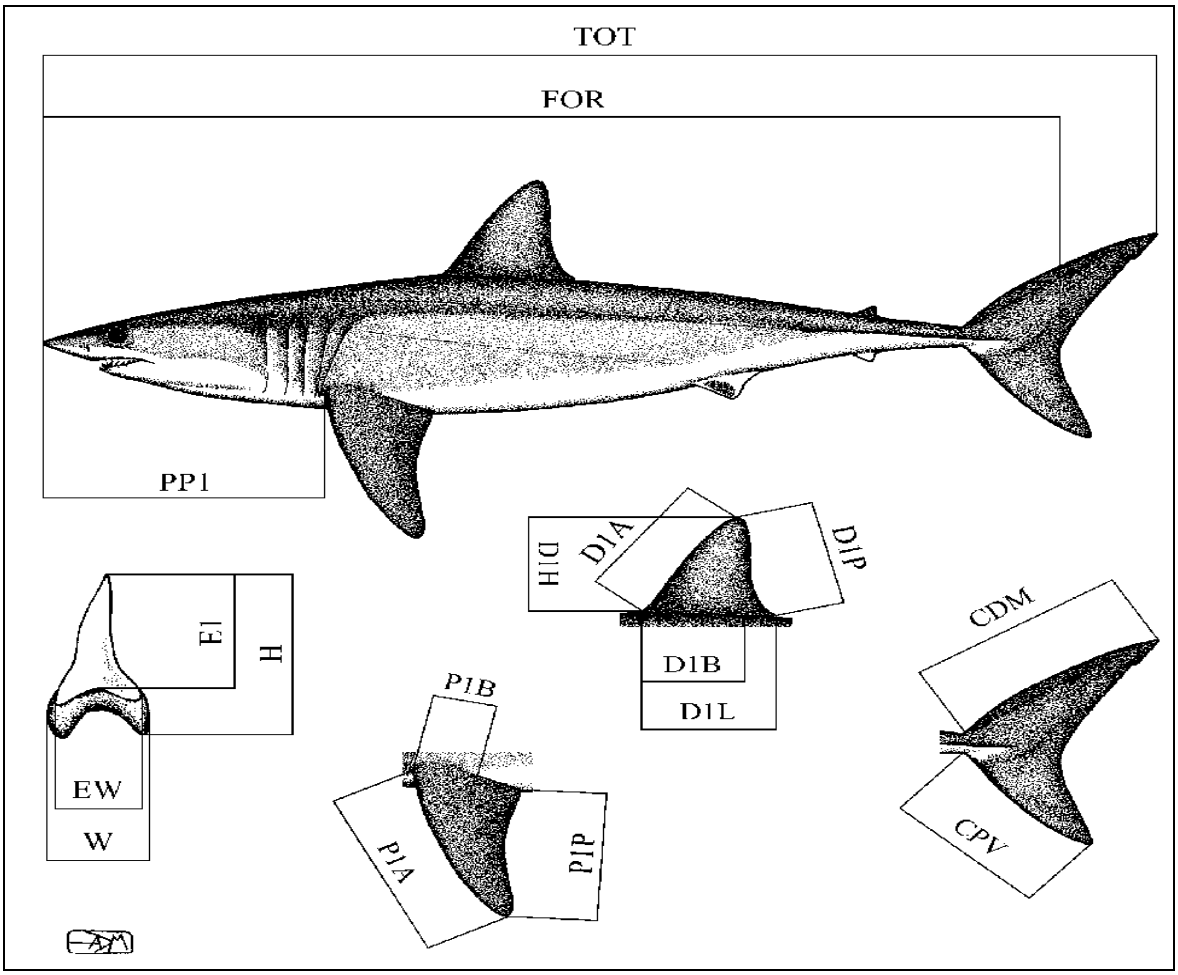

Fig. 1: Shortfin mako *Isurus oxyrinchus:* ***measurements used in this work follow the terminology and parameters of Compagno (1984) and Mollet*** *et al.* ***(1996). (Drawing: A. De Maddalena)***
Sl. 1: Atlantski mako *Isurus oxyrinchus:* ***meritve, uporabljene v tem delu, so v skladu s terminologijo in parametri Compagna (1984) in Molleta*** *et al.* ***(1996). (Risba: A. De Maddalena)***

MATERIALS AND METHODS

We collected all the data available for the two specimens presented in this work. Morphometric measurements were made following Compagno (1984) and Mollet *et al.* (1996) (Fig. 1). Photographic evidence was collected for both specimens. The pectoral fins, first dorsal fin and the jaws of the shortfin mako caught off Scaletta Zanclea were preserved by the fisherman, and eventually examined and measured by one of the authors (A. Celona). The specimen caught between Portopalo di Capo Passero and Marzamemi was thoroughly examined, its photos taken and fins preserved in one of the author's (L. Piscitelli) personal collection. Total length of the Scaletta Zanclea specimen was estimated according to the literature (Garrick, 1967; Moreno, 1991; Kohler *et al.*, 1996; De Maddalena *et al.*, 2001). Three estimates (from the pectoral fin size, from the first dorsal fin size and from the photographic evidence) were obtained and then the three resulting intervals compared. Moreover, the following relationship between fork length and total length, based on 199 specimens with lengths ranging from 70 to 368 cm, was used (Kohler *et al.*, 1996):

$$FL = (a)TL + b$$

where FL is fork length, TL total length, and a and b are 0.9286 and -1.7101, respectively.

RESULTS

A mature female shortfin mako shark was captured by fisherman F. Arturo on 26 July, 2003, off Sicily, in the Western Ionian Sea, Italy (Figs. 3–6). It was caught at 6 m depth, 3 km east of Scaletta Zanclea (Fig. 2). The sea was smooth and the north-westerly wind blowing at that time reached 4–5 knots. The mako was caught in a swordfish drift net ("spadara"), 7500 m long and 30 m high. On the same night, five swordfish were actually caught. When the fisherman crew saw the shark discussed, it was still alive and moving vigorously to escape. It was killed with two rifle shots. Some scars, maybe "love bites" or mating scars, behind the shark's gill slits were observed. The lower part of the head, under the snout and around the mouth, was dark, but lighter than the upper parts. The fisherman estimated the shark's fork length (FOR) at 420 cm and its weight at 500 kg. The shark was sold at a low price (about 300 €). Unidentified remains, almost completely digested, were found in the stomach. Data of the specimen's jaws and fins morphometrics are presented in Table 1.

Another mature female shortfin mako shark was transported to the fish market in Milan (Figs. 7, 8) on 22 June, 2004. The shark was accidentally captured 15 miles offhore between Portopalo di Capo Passero and Marzamemi, Sicily, in the Western Ionian Sea (Fig. 2), in

Fig. 2: Map of Sicily, Italy (Mediterranean Sea), showing the location of the shortfin mako captures presented in this work. (Drawing: A. De Maddalena)
Sl. 2: Zemljevid Sicilije (Sredozemsko morje) z lokalitetami ulova atlantskih makojev, opisanih v tem delu. (Risba: A. De Maddalena)

the area from which other captures of large sharks had been previously reported (Celona, 2002; De Maddalena, 2002). The mako was caught by "Vittorio Veneto" fishing vessel belonging to International Fish of Acireale, Sicily. The pelagic longline, in which the mako was caught, was actually used for catching swordfish. The about 76-km main line carried a total of 1500 6-cm hooks (Mustad hooks, the kind used more commonly for swordfish

Tab. 1: Measurements (in cm) of jaws and fins of the shortfin makos caught off Scaletta Zanclea and between Portopalo di Capo Passero and Marzamemi, Sicily.
Tab. 1: Velikost (v cm) čeljusti in plavuti dveh atlantskih makojev, ujetih v bližini Scalette Zanclee ter med Portopalom di Capo Passero in Marzamemijem, Sicilija.

Shortfin mako caught on 26 July, 2003 (off Scaletta Zanclea)				
Dental formula	12 – 12 / 12 – 12			
Dried upper jaw perimeter	80			
Dried lower jaw perimeter	69			
1st upper anterior tooth	3.7 (E1)	1.9 (EW)	2.5 (W)	5.3 (H)
2nd upper anterior tooth	3.0 (E1)	2.0 (EW)	2.9 (W)	4.7 (H)
Upper intermediate tooth	1.5 (E1)	1.8 (EW)	2.0 (W)	2.9 (H)
1st lower anterior tooth	3.5 (E1)	1.5 (EW)	2.3 (W)	4.5 (H)
2nd lower anterior tooth	3.7 (E1)	1.8 (EW)	2.5 (W)	4.8 (H)
3rd lower anterior tooth	2.3 (E1)	2.3 (EW)	2.4 (W)	3.5 (H)
Pectoral anterior margin (P1A)	66 (measured dried)			
Pectoral posterior margin (P1P)	57 (measured dried)			
1st dorsal anterior margin (D1A)	44 (measured dried)			
1st dorsal posterior margin (D1P)	43 (measured dried)			
1st dorsal height (D1H)	39 (measured dried)			
Shortfin mako caught between Portopalo di Capo Passero and Marzamemi				
Total length (TOT)	370 (measured frozen)			
Pectoral anterior margin (P1A)	71 (measured frozen)			
Pectoral base (P1B)	12 (measured frozen)			
1st dorsal length (D1L)	35 (measured frozen)			
1st dorsal base (D1B)	25 (measured frozen)			
1st dorsal height (D1H)	42 (measured frozen)			
Dorsal caudal margin (CDM)	61 (measured frozen)			
Preventral caudal margin (CPV)	56.5 (measured frozen)			

fishing in the Mediterranean), at intervals of about 51 m. The baits used were the Atlantic mackerel *Scomber scombrus* Linnaeus, 1758 and the European squid *Loligo vulgaris* Lamarck, 1798 (Mr. Castorina and A. Leonardi, *pers. comm.*). The gutted mako was 370 cm long and weighed 330 kg. The shark lacked the jaws, which had been cut off after its capture. This specimen also lacked the left pelvic fin, bearing a healed scar apparently inflicted by another shark's bite (Fig. 8). Its morphometrics are presented in Table 1.

DISCUSSION

Kohler *et al.* (1996) reported the relationship between fork length and total length of the shortfin mako as FL = (0.9286)TL – 1.7101. We then estimated that the Scaletta Zanclea specimen's total length, according to this relationship and the fork length reported by the fisherman, was 454 cm. If the estimate is correct, this specimen should be the largest of its species ever recorded, surpassing even the huge 445-cm shortfin mako reported by Capapé (1977). We decided to check the validity of this estimate using the elements at our disposal. There are three different estimates that can be obtained from the available materials: from the pectoral fin size, from the first dorsal fin size, and from the photographic evidence.

The shortfin mako shows changes in morphology with size. Therefore, only data obtained from the measurements of large specimens can be utilised as a useful reference to effect a precise size estimate of the Scaletta Zanclea specimen. We used the measurements of three shortfin makos of 246, 270 and 296 cm in length, compiled by Moreno (1991) (Tab. 2).

Tab. 2: Data obtained from the measurements of three shortfin makos of 246, 270 and 296 cm in length, compiled by Moreno (1991). Measurements (following terminology and parameters of Compagno, 1984) are expressed as percentage of total length.
Tab. 2: Podatki, ki jih je na osnovi meritev treh atlantskih makojev, dolgih 246, 270 in 296 cm, zbral Moreno (1991). Meritve (po terminologiji in parametrih Compagna, 1984) so podane kot odstotek celotne dolžine.

Measurement	**Abbreviation**	**%TOT**
Prepectoral length	PP1	28.3 – 29.2
Pectoral anterior margin	PlA	18.4 – 19.2
1st dorsal height	DlH	10.1 – 10.9

Fig. 3: Estimated 390-cm female shortfin mako caught on 26 July, 2003, off Scaletta Zanclea, Sicily. (Photo: G. Manganaro)
Sl. 3: Samica atlantskega makoja, ujeta 26. 7. 2003 v bližini Scalette Zanclee, Sicilija, je po oceni avtorjev v dolžino merila 390 cm. (Foto: G. Manganaro)

Fig. 4: Head of the estimated 390-cm female shortfin mako caught on 26 July, 2003, off Scaletta Zanclea. (Photo: G. Manganaro)
Sl. 4: Glava 390 cm dolge samice atlantskega makoja, ujete 26. 7. 2003 v bližini Scalette Zanclee. (Foto: G. Manganaro)

It is important to note that while fins of the mako caught between Portopalo di Capo Passero and Marzamemi were measured frozen, which means that their size was very close to the size of the fresh ones, the fins of the specimen caught off Scaletta Zanclea were measured dried, about five months after capture, which means that their size may be conspicuously smaller than of the fresh fins. Therefore we need to consider a shrinkage between 3.8 and 7.4% for the Portopalo di Capo Passero specimen (Duffy & Francis, 2001) and between 10% and 15% for the Scaletta Zanclea specimen (Mollet *et al.*, 1996). The original P1A of the Scaletta Zanclea specimen should therefore be between 73 and 78 cm, and the original D1H between 43 and 46 cm. We estimated the TOT to be 380–424 cm on the basis of P1A, and 394–455 cm on the basis of D1H.

Following the indications given by De Maddalena *et al.* (2001) for estimating the size of large sharks from photographic evidences, we concluded that one of the photographs (Fig. 4) of the Scaletta Zanclea mako is applicable to produce an accurate estimate of this specimen. We assumed as references the body of the man on the right of the photograph, and the hand of the man on the left. We then estimated the PP1 at 94–110 cm, corresponding to 322–389 cm TOT.

Finally, comparing the three intervals obtained from these three estimates (322–389 cm, 380–424 cm, 394–455 cm TOT), we concluded that the total length of Scaletta Zanclea specimen should be about 390 cm. Therefore the 420-cm fork length estimated by the fisherman seems to be exaggerated. However, the two specimens reported in this work are the largest ever recorded in Sicilian waters, and among the largest recorded from the entire Mediterranean Sea.

Fig. 5: Anterior view of the estimated 390-cm female shortfin mako caught on 26 July, 2003, off Scaletta Zanclea. (Photo: G. Manganaro)
Sl. 5: Pogled od spredaj na 390 cm dolgo samico atlantskega makoja, ujeto 26. 7. 2003 v bližini Scalette Zanclee. (Foto: G. Manganaro)

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Fig. 6: Tooth of the estimated 390-cm female shortfin mako caught on 26 July, 2003, off Scaletta Zanclea. (Photo: G. Manganaro)
Sl. 6: Zob 390 cm dolge samice atlantskega makoja, ujete 26. 7. 2003 v bližini Scalette Zanclee. (Foto: G. Manganaro)

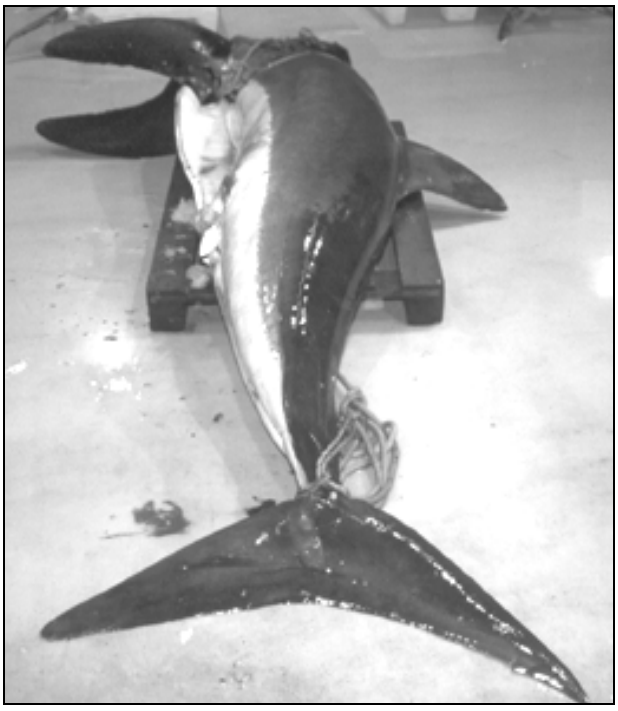

Fig. 7: The 370-cm female shortfin mako caught between Portopalo di Capo Passero and Marzamemi, Sicily, and examined at the fish market in Milan on 22 June, 2004. (Photo: L. Piscitelli)
Sl. 7: 370 cm dolg atlantski mako, ujet med Portopalom di Capo Passero in Marzamemijem na Siciliji ter 22. junija 2004 izmerjen na ribji tržnici v Milanu. (Foto: L. Piscitelli)

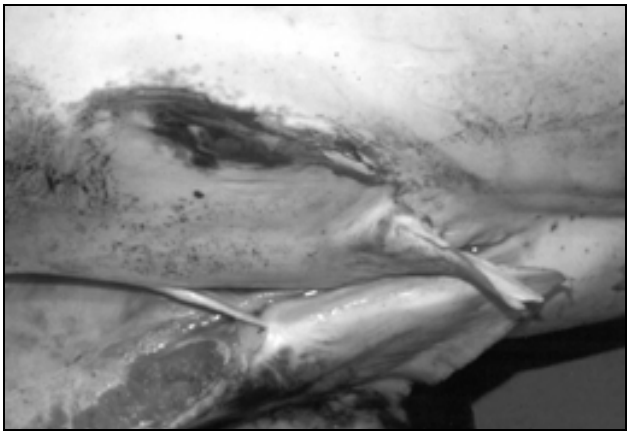

Fig. 8: Pelvic region of the 370-cm female shortfin mako caught between Portopalo di Capo Passero and Marzamemi, lacking the left pelvic fin and bearing a healed scar apparently inflicted by another shark's bite. (Photo: L. Piscitelli)
Sl. 8: Trebušni del 370 cm dolgega atlantskega makoja, ujetega med Portopalom di Capo Passero in Marzamemijem, brez leve trebušne plavuti, a z zaceljeno brazgotino, ki je najbrž posledica ugriza kakega drugega morskega psa. (Foto: L. Piscitelli)

PRIMER DVEH IZREDNO VELIKIH ATLANTSKIH MAKOJEV *ISURUS OXYRINCHUS*, RAFINESQUE, 1809, UJETIH V VODAH ZAHODNEGA JONSKEGA MORJA NEDALEČ OD SICILIJE

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POVZETEK

Avtorji pričujočega članka poročajo o dveh nenavadno velikih atlantskih makojih Isurus oxyrinchus, *ujetih nedaleč od Sicilije v vodah zahodnega Jonskega morja. Prvi primerek, samica atlantskega makoja, je bil ujet 26. julija 2003 blizu Scalette Zanclee. Na osnovi fotografije in izmerjenih dolžin prsne plavuti in prve hrbtne plavuti je bila ocenjena samičina celotna dolžina, in sicer 390 cm. Drugi primerek, 370 cm dolga samica, je bil ujet 22. junija 2004 med Portopalom di Capo Passero in Marzamemijem in prepeljan na ribjo tržnico v Milanu. Primerka sta največja, kar so jih kdaj ujeli v sicilskih vodah in med največjimi, kar jih je bilo kdaj zabeleženih v celotnem Sredozemskem morju.*

Ključne besede: atlantski mako, *Isurus oxyrinchus*, velikost, Sredozemsko morje

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THE MEDITERRANEAN SPEARFISH, *TETRAPTURUS BELONE* RAFINESQUE, 1810, IN THE ADRIATIC WATERS: NEW RECORD AND A REVIEW OF ADRIATIC RECORDS

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ABSTRACT

Two specimens of the Mediterranean spearfish, Tetrapturus belone *Rafinesque, 1810, were caught in June 2004 in the eastern central Adriatic. The data on their total length and weight are given. In spite of a number of scientific records (21) regarding this species, it could be treated as a rare species in the Adriatic.*

Key words: Mediterranean spearfish, records, Adriatic Sea

AGUGLIA IMPERIALE MEDITERRANEA, *TETRAPTURUS BELONE* RAFINESQUE, 1810, NELLE ACQUE DELL'ADRIATICO: UN NUOVO DATO E RASSEGNA DELLE ANNOTAZIONI PRECEDENTI

SINTESI

Nel giugno del 2004, nelle acque dell'Adriatico centro–orientale, sono stati catturati due esemplari di aguglia imperiale mediterranea, Tetrapturus belone *Rafinesque, 1810. L'autore ne riporta la lunghezza ed il peso. Anche se non mancano appunti scientifici sulla presenza della specie nel Mare Adriatico (21), possiamo considerarla una specie adriatica rara.*

Parole chiave: aguglia imperiale mediterranea, annotazioni, Mare Adriatico

INTRODUCTION

The Mediterranean spearfish, *Tetrapturus belone* Rafinesque, 1810 (Fig. 1), is a marine and bathypelagic species living in the Mediterranean (considerably abundant around Italy) (Nakamura, 1986). No confirmed report from the Black Sea and no adults have been reported east of the Ionian Sea (Nakamura, 1986). The data on biology and ecology of this species are very scarce (Nakamura, 1985, 1986). This highly migratory species is the most common istiophorid in the central basin of the Mediterranean and completes its life cycle inside this sea as far as known to date. It probably swims in the upper 200 m water layer, generally above or within the thermocline. It travels in pairs, possibly corresponding to the feeding behaviour. It feeds on fishes (Nakamura, 1985, 1986). This species is very rare in the Adriatic Sea (Jardas, 1985, 1996).

The data on biology and ecology of this species are very scarce. The aim of this paper is to provide new additional data on their capture and distribution in the Adriatic Sea.

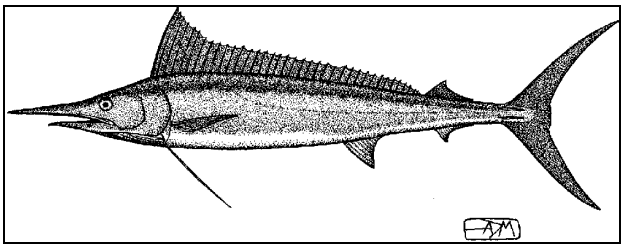

Fig. 1 / Sl. 1: *Tetrapturus belone* ***Rafinesque, 1810. (Drawing / Risba: A. De Maddalena)***

MATERIAL AND METHODS

Two specimens of the Mediterranean spearfish were caught in the eastern central Adriatic (specimen 1: Vela Luka harbour, Korčula Island, on 20 June 2004; specimen 2: near Sušac Island, on 27 June 2004) (Fig. 2, location F). Both specimens were harpooned at the surface, subsequently measured to the nearest cm, and weighed to the nearest g. The specimens were identified according to Jardas (1996). We were not in position to take morphometric data, as fishermen prepared the specimens for the market immediately after their capture.

RESULTS AND DISCUSSION

Total length of specimen 1 (Fig. 3) was TL = 186.0 cm, weight W = 2300 g. Total length of specimen 2 (Fig. 4) was TL = 180.0 cm, weight W = 1850 g. It could reach 240 cm (Nakamura, 1986) or 250 cm in total

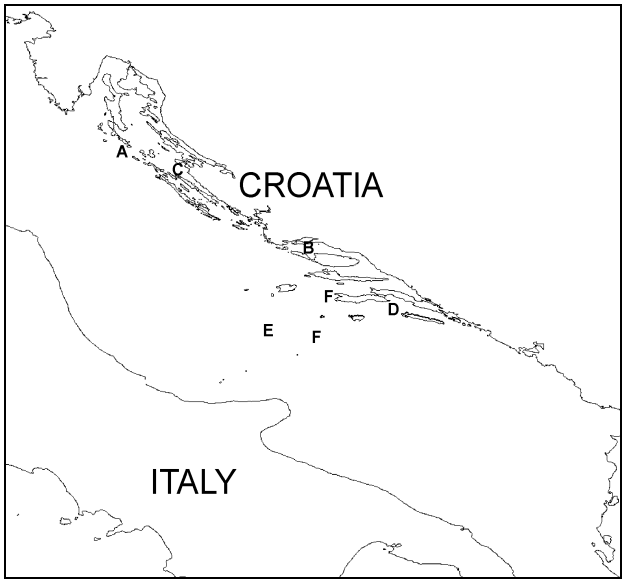

Fig. 2: Some localities where Mediterranean spearfish have been caught in the Adriatic: A – Lošinj Island, B – Kaštela Bay, C – Vrgada Island, D – Lumbarda (island of Korčula), E – open waters in the central Adriatic, F – Sušac Island and Vela Luka harbour (island of Korčula).
Sl. 2: Nekaj jadranskih lokacij, na katerih je bila ujeta sredozemska suličica: A – Lošinj, B – Kaštelanski zaliv, C – otok Vrgada, D – Lumbarda (Korčula), E – odprto morje v srednjem Jadranu, F – otok Sušac in pristanišče Vela Luka (Korčula).

length (Jardas, 1996). Maximal published weight is 70 kg (Nakamura, 1985), while Milišić (1994) reported the weight of 80 kg.

The first record of this species in the Adriatic was made by Nardo (1827), the second in 1846 (Trois, 1880). Gridelli (1931) noted that this species was rare

Fig. 3: *Tetrapturus belone* ***caught in Vela Luka harbour, island of Korčula (TL = 186 cm, W = 2300 g).***
Sl. 3: Primerek vrste *Tetrapturus belone****, ujet v pristanišču Vela Luka na Korčuli (TL = 186 cm, W = 2300 g).***

and he described a specimen caught near the island of Lošinj (northern Adriatic, Croatian coast) in 1930 (Fig. 2, location A). Kolombatović (1881) reported on a female specimen caught in Kaštela Bay (central Adriatic, Croatian coast) in 1879 with TL = 195 cm (Fig. 2, location B). Kolombatović (1886) also reported (as a *Histiophorus belone* Günther, 1860) on four specimens caught near Supetar (island of Brač), and five specimens caught near Jelsa (island of Hvar), but without any data on their size and weight. Katurić (1887) described a single specimen (TL = 186 cm) captured near the island of Vrgada (central Adriatic, Croatian coast) (Fig. 2, location C). Katurić (1887) also caught a specimen in 1886, describing it in details. Two specimens were caught in high sea (central Adriatic) in 1957 (Fig. 2, location E): the first specimen TL = 190 cm, W = 19 kg (without its stomach); the second specimen TL ≈ 185 cm (no data for weight) (Morović, 1984). Milišić (1994) reported on the catch of two adult specimens near the Neretva estuary in 1958. Kršinić (1970) reported on a specimen captured near the village of Lumbarda (Korčula Island) (southern Adriatic, Croatian coast) (Fig. 2, location D), with TL = 210 cm and W = 35 kg. Milišić (1994) reported on the catch of one specimen (TL = 185.0 cm, W = 49 kg) in Žukova Cove (island of Hvar). It is obvious that most of the records (14) have been made in the eastern central Adriatic. According to Morović (1973), the rarity of certain fish species could be evaluated from the records in scientific literature. The same author has pointed out that if the species is recorded less than five times, it should be treated as a very rare species, and as a rare species if recorded between six and twenty times. According to this suggestion we could still treat the Mediterranean spearfish as a rare species (21 records in scientific literature to date).

Fig. 4: *Tetrapturus belone* ***caught near island of Sušac (TL = 180 cm, W = 1850 g).***
Sl. 4: Primerek vrste *Tetrapturus belone****, ujet v bližini otoka Sušac (TL = 180 cm, W = 1850 g).***

SREDOZEMSKA SULIČICA, *TETRAPTURUS BELONE* RAFINESQUE, 1810, V JADRANSKIH VODAH: NOV PODATEK IN PREGLED PREJŠNJIH ZAPISOV O TEJ VRSTI IZ JADRANSKEGA MORJA

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POVZETEK

Junija 2004 sta bili v vzhodnem srednjem Jadranu ujeti dve sredozemski suličici, Tetrapturus belone *Rafinesque, 1810. V članku avtorja navajata podatke o celotni dolžini in teži ujetih sredozemskih sulčic. Čeprav obstaja kar nekaj znanstvenih zapisov o pojavljanju te vrste v Jadranskem morju (21), bi jo lahko šteli za redko jadransko vrsto.*

Ključne besede: sredozemska suličica, zapisi, Jadransko morje

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RECORDS OF THE BERMUDA SEA CHUB, *KYPHOSUS SECTATOR* (LINNAEUS, 1758) (OSTEICHTHYES: KYPHOSIDAE) FROM THE COASTAL WATERS OF ALGERIA (SOUTHERN MEDITERRANEAN)

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ABSTRACT

The paper reports on the first record of Bermuda sea chub Kyphosus sectator *(Linnaeus, 1758) from the Algerian coastal waters. A short description of the species is given and its occurrence in the Mediterranean Sea commented upon and discussed.*

Key words: Osteichthyes, Kyphosidae, *Kyphosus sectator*, coast of Algeria, Mediterranean Sea

AVVISTAMENTI DI PESCE TIMONE *KYPHOSUS SECTATOR* (LINNAEUS, 1766) (OSTEITTI: KYPHOSIDAE) AL LARGO DELLA COSTA ALGERINA (MEDITERRANEO MERIDIONALE)

SINTESI

L'articolo riporta le prime segnalazioni della presenza del pesce timone Kyphosus sectator *(Linnaeus, 1766) al largo della costa algerina. Gli autori ne forniscono una breve descrizione, nonché commentano e discutono la presenza della specie nel mare Mediterraneo.*

Parole chiave: Osteitti, Kyphosidae, *Kyphosus sectator*, costa algerina, mare Mediterraneo

INTRODUCTION

The Bermuda sea chub, *Kyphosus sectator* (Linnaeus, 1758) has been reported from the eastern Atlantic Ocean, south Strait of Gibraltar, between the coast of Morocco and the Gulf of Guinea. However, it has not been commonly landed at the area's fishing sites (Cadenat, 1950; Fischer *et al.*, 1981; Desoutter, 1990; Séret & Opic, 1990).

K. sectator is 'rarely found in the Mediterranean' according to Tortonese (1975, 1986). Of the four Mediterranean records reported to date, three were earlier: a specimen caught off Trieste (northern Adriatic) in 1847 (Šoljan, 1975), off Sicily (Doderlein, 1889), in the Gulf of Genoa (Ariola, 1904); a single specimen was recently recorded off the Balearic Islands (Merella *et al.*, 1998).

MATERIAL AND METHODS

On 3, 4 and 7 June 2003, a number of Bermuda sea chubs were being sold at Algiers fish market (Fig. 1). According to the fishermen, the specimens were captured by gill-nets at depth between 10 and 20 m and by trawling at unknown depth, off Annaba, the town located on the eastern Algerian coast some 90 km west of the Tunisian border (Fig. 2). *K. sectator* had previously not been reported off the Algerian coast (Dieuzeide *et al.*, 1953; Lalami, 1971; Djabali, 1993; Derbal & Kara, 2001). The present article presents the first record of the Bermuda sea chub in the Algerian waters and briefly comments on the Mediterranean distribution of the species.

RESULTS AND DISCUSSION

As the specimens were immediately sold by the fishermen, we were unfortunately unable to preserve and include them in the Ichthyological Collection of the Algiers University. However, measurements, counts and mass were made in a single specimen. They are presented in Table 1. This specimen is described as follow: body rather oval and compressed; head, body and fins entirely covered with small ctenoid scales; snout profile convex; mouth small with an outer series of incisors having large roots within the jaws and on palate; eyes rounded; pectoral short and rounded; soft dorsal lower than spinous. Colour of the body uniformly bluish-grey with lines slightly yellowish along head and body; opercular membrane blackish.

Measurements, counts, description and colour are in agreement with Tortonese (1975, 1986), Fischer *et al.* (1981) and Séret & Opic (1990).

Fig. 1: A number of Bermuda sea chubs captured off the eastern Algerian coast and observed at Algiers fish market.
Sl. 1: Primerki vrste *Kyphosus sectator****, ujeti v bližini vzhodne alžirske obale in pripeljani na ribjo tržnico v Alžiru.***

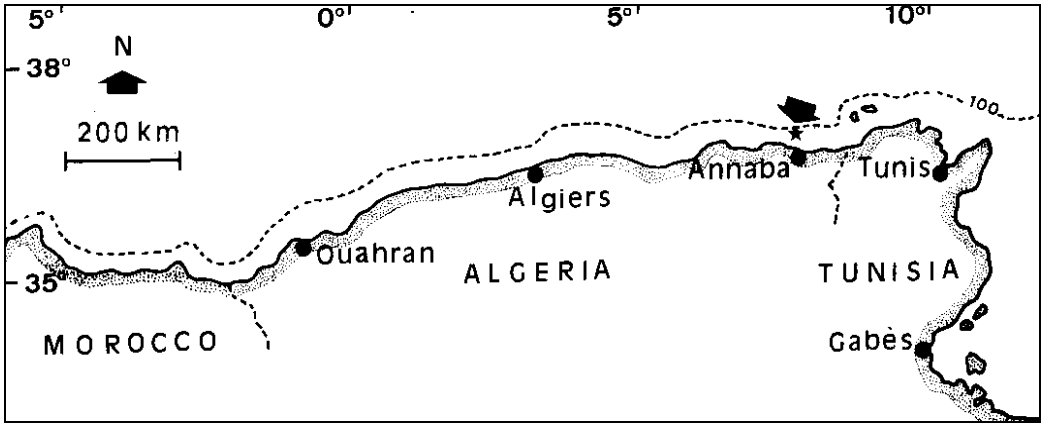

Fig. 2: Map of the Maghrebin shore showing the fishing site (pointed out by a black star) of *Kyphosus sectator****.***
Sl. 2: Zemljevid Magrebskega obrežja z označeno lokaliteto vrste *Kyphosus sectator* ***(črna zvezdica).***

With regard to some species such as *K. sectator*, Quignard & Tomasini (2000) noted: *'The discovery of a large number of other species outside of their usual area of distribution may be due to the increase of traditional prospection, or the use of newer techniques which allow the exploration of otherwise inaccessible habitat'.* This agrees with Golani (1996), Golani & Sonin (1996) and Hemida *et al.* (2003).

K. sectator was recorded for the first time in the Mediterranean Sea in 1847 (Šoljan, 1975); between then and the record made by Merella (1998), the species was reported three times only. Tortonese (1975, 1986) reports only on the three mentioned records made off Trieste, Sicily and Genoa.

These rare records do not allow to state *a priori* that *K. sectator* populations have been successfully established in Mediterranean areas even if the recent Bermuda sea chub findings off the Algerian coast are more or less in agreement with Quignard & Tomasini's opinion (2000).

Records of shark and teleost species (Hemida *et al.*, 2002, 2003) originating from the eastern tropical Atlantic along the Algerian shore corroborate Quignard & Tomasini (2000) who suggest the role of the Strait of Gibraltar in the increasing Mediterranean fish biodiversity. This is concomitant with the Mediterranean occurrence of species originating and regularly recorded from the Red Sea (Quignard & Tomasini, 2000; Dulčić *et al.*, 2003). These observations could be explained by the present waters warming off France (Francour *et al.*, 1994; Francour & Javel, 2003), in the Adriatic (Dulčić, 1998; Dulčić *et al.*, 1999), off Tunisia (Bradaï, 2000) and off Algeria (Kara & Bourehail, 2003).

***Tab. 1: Morphometric measurements and counts in one specimen of** Kyphosus sectator.*
***Tab. 1: Morfometrični podatki osebka vrste** Kyphosus sectator.*

Measurements (mm)	
Total length	485
Length to furk	455
Standard length	380
Head length	55
Interorbital space	35
Eye diameter	15
Preorbitar length	33
Postorbitar length	49
Caudal peduncle height	38
Space between snout and vent	280
Prepectoral fin length	99
Postpectoral fin length	92
Dorsal fin length	170
Pelvic fin length	60
Anal fin length	160
Caudal fin length	141
Body height	151
Body depth	40
Height of caudal fin peduncle	45
Mass (g)	675
Counts	
Dorsal fin rays	XI + 12
Anal fin rays	III + 12

PRVI PODATKI O VRSTI *KYPHOSUS SECTATOR* (LINNÉ, 1758) (OSTEICHTHYES: KYPHOSIDAE) IZ OBREŽNIH VODA ALŽIRIJE (JUŽNO SREDOZEMLJE)

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POVZETEK

Avtorji pričujočega prispevka poročajo o prvem pojavljanju vrste Kyphosus sectator *(Linnaeus, 1758) v obrežnih vodah Alžirije. Podajajo kratek opis vrste in razpravljajo o njenem pojavljanju v Sredozemskem morju.*

Ključne besede: Osteichthyes, Kyphosidae, *Kyphosus sectator*, obrežne vode Alžirije, Sredozemsko morje

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NEUROLEON MICROSTENUS (MCLACHLAN, 1898) (NEUROPTERA: MYRMELEONTIDAE) IN NORTHWESTERN PART OF THE BALKAN PENINSULA

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ABSTRACT

Results of the study of the antlion species Neuroleon microstenus *are described and figured. Distribution of the species in the northwestern part of the Balkan Peninsula and some information on biology of the species are presented. The species was found for the first time in Slovenia and the distribution in Croatia and Montenegro was confirmed. Two dark pigmented spots in forewings are characteristic for the species. The length of distal spot varies and comprises an area of 2-4 cross-veins. The only known finding-place in Slovenia has been destroyed and consequently the species seems to be extinct there.*

Key words: *Neuroleon microstenus*, antlions, Neuroptera, ecology, endangerment, Balkan Peninsula

NEUROLEON MICROSTENUS (MCLACHLAN, 1898) (NEUROPTERA: MYRMELEONTIDAE) NELL'AREA NORD – OCCIDENTALE DELLA PENISOLA BALCANICA

SINTESI

Nella parte nord – occidentale della penisola balcanica, la specie di formicaleone Neuroleon microstenus *è diffusa in Slovenia, Croazia e Montenegro. La specie si distingue per le chiazze scure sulle ali anteriori. La lunghezza della chiazza distale varia; la chiazza copre un'area che va da due a quattro nervature trasversali. La popolazione presente in Slovenia è minacciata; vengono presentati alcuni dati relativi al suo habitat. Nell'unico luogo di insediamento noto in Slovenia, la specie è stata sterminata.*

Parole chiave: *Neuroleon microstenus*, formicaleoni, Neurotteri, ecologia, minaccia, penisola balcanica

INTRODUCTION

The antlions, Myrmeleontidae, are well known even to non-entomologists due to their unique method of capturing their prey. In pit-building species, the larva digs a conical pit in sand or loose soil and then waits for prey at the bottom of the pit.

Antlions occur in warmer parts of the world; the Mediterranean Basin is one of their distribution centres.

The genus *Neuroleon* Navás, 1909 includes small antlions and is confined to Africa, southern Europe and large parts of Asia (Hölzel, 1986). There are about 120 valid species of the genus, but only two of them occur in the western part of the Balkan Peninsula (Aspöck *et al.*, 2001). Till now, both Balkan species – *Neuroleon microstenus* (McLachlan) and *Neuroleon egenus* (Navás) – have been reported from Croatia (Devetak, 1992a, b). Knowledge of ecology and distribution of *Neuroleon* species is poor; usually only single specimens have been collected in European countries. The only exception in this respect is France, where Steffan (1971) studied ecology and distribution of the genus in detail. The larva of *N. microstenus* lives in sand without constructing pits (Gepp, 1974; Gepp & Hölzel, 1989).

N. microstenus is a polycentric Mediterranean species (for review of distribution see Aspöck *et al.*, 2001). Morphology of the first instar larvae was described by Gepp (1974). *N. microstenus* can easily be distinguished from other *Neuroleon* species following key-characters (Aspöck *et al.*, 1980). Among the other characters, abdomen of males of this species is much longer than the wings.

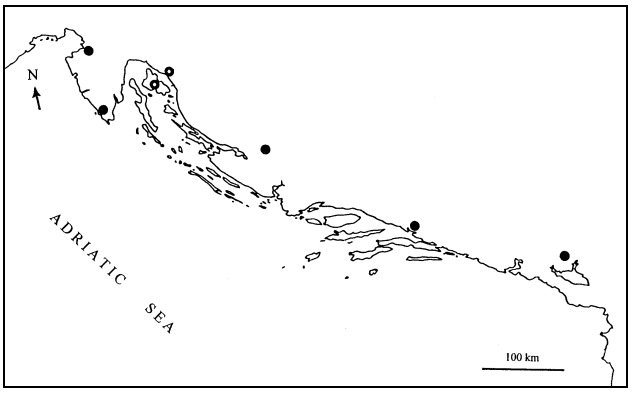

Fig. 1: Collecting places of** Neuroleon microstenus **in the northwestern part of the Balkan Peninsula. Localities with individuals collected before 1950 are marked with open circles (o).
Sl. 1: Razširjenost volkcev vrste** Neuroleon microstenus **v severozahodnem delu Balkanskega polotoka. Lokalitete s primerki, nabranimi pred letom 1950, so prikazane s praznimi krogci (o).

In 2001, *N. microstenus* was found in Slovenia. Very little is known about the habitat preference of this species. According to Aspöck *et al.* (1980), the species occurs in forests or macchia; our finding in Slovenia does not confirm this as, contrary to this, the species is linked to an open area devoid of trees and bushes.

In this paper, the distribution of *N. microstenus* in the northwestern part of the Balkan Peninsula and some information on biology of the species are presented.

MATERIAL AND METHODS

Fluid-preserved and dried specimens are deposited in the Natural History Museum, Zagreb, Croatia (coll. Museum ZG) and in the first author's collection (Maribor).

Wing morphology was examined microscopically. Habitat temperatures were measured with digital thermometers Cresta and Checktemp, Hanna Instruments.

RESULTS AND DISCUSSION

Distribution in the northwestern part of the Balkan Peninsula

Literature records: Devetak (1992b): Croatia: Novi, Krk, Stoja

Material examined (m – males, f - females)

Slovenia: Koper, Srmin 7.VIII.2001 3m 8f, D. Devetak leg.; 17.VIII.2001 1f P. Devetak leg.

Croatia: Pula, Stoja 10.VIII.1983 1m, D. Devetak leg.; Novi VIII.1939 1m (coll. Museum ZG); Krk: Krk VIII. 1949 1m (coll. Museum ZG); Obrovac, Golubić, rijeka Krupa 8.VIII.1984 1f, M. Franković leg. (coll. Museum ZG); Ploče, Blace 3.VIII.1996 1f F. Perović leg., 1f G. Gjerapić leg. (coll. Museum ZG).

Montenegro: Tuzi 12.VIII.1982 2f, 15.VIII.1982 1m 2f, 24.VIII.1092 2m 1f, 27.VIII.-4.IX.1982 4f, 5.-17.IX. 1982 2f; all F. Janžekovič leg.

The finding places in the northwestern part of the Balkan Peninsula are shown in figure 1.

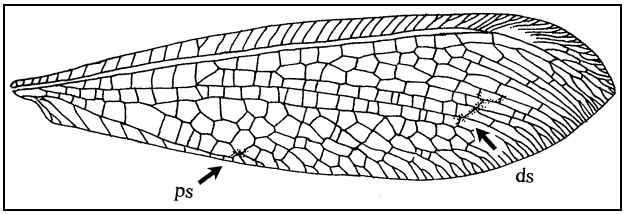

Fig. 2: Right forewing of** Neuroleon microstenus **(Golubić, Croatia). The proximal (ps) and distal spots (ds) are marked with arrows. The wing is 22 mm long.
Sl. 2: Desno sprednje krilo volkca vrste** Neuroleon microstenus **(Golubić, Hrvaška). Proksimalna (ps) in distalna lisa (ds) sta označeni s puščicama. Dolžina krila je 22 mm.

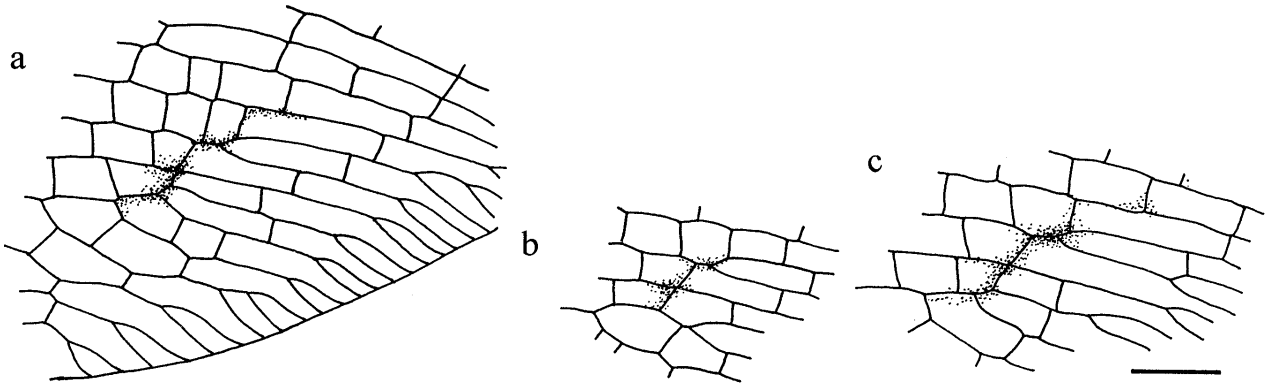

Fig. 3: Variability of the distal spot in right forewings: a, b – females from Srmin near Koper (Slovenia); c – male from Tuzi (Montenegro). Bar: 1 mm.
Sl. 3: Variabilnost distalne lise v desnih sprednjih krilih: a, b – samici s Srmina pri Kopru; c – samec iz Tuzija (Črna gora). Merilo: 1 mm.

Wing morphology and pigmentation

Forewings are shown in figures 2 and 3. Two dark pigmented spots are characteristic of this species, the proximal and distal ones. The length of the distal spot varies and comprises an area of 2-4 cross-veins (Fig. 3). However, we did not note geographically correlated variability.

Fig. 4: Dry eroded flysch slopes at Srmin near Koper (Slovenia) in August 2001. This collecting place is now destroyed.
Sl. 4: Suha in erodirana flišnata pobočja hriba Srmina pri Kopru v avgustu 2001. Ta lokaliteta je danes uničena.

Remarks on the habitat

According to Aspöck *et al.* (1980), the typical habitats of the species are forests or macchia. In Croatia (Stoja in the vicinity of Pula), the species originates from macchia, while in Slovenia (Srmin near Koper) *N. microstenus* populated an area devoid of vegetation (Fig. 4). In this place, numerous individuals were observed on August 2001 flying along dry eroded flysch slopes. The maximal ground temperatures (1 cm depth) in Srmin in summer reached 62 °C and the maximal air temperature 50 °C (200 cm height, 17 August 2001) (Tab. 1). Despite the extremely high temperatures, antlions were still actively flying.

Endangerment in Slovenia

During 2002 and 2003, the only known finding-place in Slovenia was destroyed as material excavated during road construction was deposited in Srmin and the eroded flysch slopes were filled up. The species seems to be extinct in Slovenia.

ACKNOWLEDGEMENTS

We thank Dr Franjo Perović (Natural History Museum, Zagreb, Croatia) for the loaned material and Prof. Dr Franc Janžekovič (Department of Biology, University of Maribor) for providing the specimens. Our thanks are also due to Prof. Dr Tone Novak (Department of Biology, University of Maribor) and an anonymous reviewer for the critical reading of the manuscript. This study was partly supported by research grant from the Ministry of Education, Science and Sports of Slovenia (Grant No. P1-0078 Biodiversity).

Tab. 1: Air and sand temperatures in Srmin (near Koper, Slovenia) at different depths on two clear days in August 2001 and June 2003.
Tab. 1: Temperature zraka in peska v Srminu pri Kopru v različnih globinah med dvema sončnima dnevoma avgusta 2001 in junija 2003.

Date/Time	Sand temperatures			Air temperatures	Weather conditions
	surface	1 cm depth	10 cm depth	200 cm height	
17 Aug 2001					
11:55	41	45	-	31.5	Cloudy day, no wind
12:00	46.5	48	-	35	Clear day, no wind
12:40	50	49	-	38	Clear day, no wind
13:15	52	62	-	50	Clear day, no wind
10 Jun 2003					
11:30	55.6	55.7	40.5	37.2	Clear day, light wind
11:45	56.6	53.7	40.5	37.2	Clear day, light wind
11:50	54.5	55.3	40.1	37.2	Clear day, light wind
12:00	57.3	57.7	40.5	35.8	Clear day, light wind
12:15	58.0	57.3	-	-	Clear day, light wind
12:20	58.1	56.1	43.4	35.5	Clear day, light wind
12:30	58.3	56.6	43.6	37.7	Clear day, light wind
12:45	57.1	56.4	43.6	37.2	Clear day, light wind
12:50	60.3	59.4	44.1	38.5	Clear day, no wind

NEUROLEON MICROSTENUS (MCLACHLAN, 1898) (NEUROPTERA: MYRMELEONTIDAE) V SEVEROZAHODNEM DELU BALKANSKEGA POLOTOKA

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POVZETEK

Vrsta volkcev Neuroleon microstenus *je v severozahodnem delu Balkanskega polotoka razširjena v Sloveniji, na Hrvaškem in v Črni gori. Za vrsto sta značilni temno pigmentirani lisi v sprednjih krilih. Dolžina distalne lise variira; lisa pokriva območje od dveh do štirih prečnih žilic. Za populacijo, ki živi v Sloveniji, navajava ogroženost in nekaj podatkov o habitatu. Na edinem znanem slovenskem nahajališču je vrsta iztrebljena.*

Ključne besede: *Neuroleon microstenus*, volkci, Neuroptera, ekologija, ogroženost, Balkanski polotok

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PRELIMINARY INVESTIGATION OF THE SEDIMENTARY BOTTOM DECAPOD FAUNA IN THE UPPER INFRALITTORAL OF THE ISLAND OF KRK (ADRIATIC SEA)

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ABSTRACT

The UNEP Mediterranean Action Plan Draft Reference List of Habitat Types of Conservation Interest includes sedimentary bottom infralittoral biocenoses. Such habitats are very rare on the eastern Adriatic coast. Therefore an investigation of the decapod fauna collected by means of a beach seine on the upper infralittoral (at the depth of ca. 0-1 m) has been carried out on three shores of Krk Island (northern Adriatic). Each locality is characterized by a different kind of sedimentary substrate (mud, sand, gravel). The species composition, their abundance and dominance are given for each locality, upon which a comparative study was conducted. Each locality has its specific dominant species. Carcinus aestuarii *is the dominant species on the muddy bottom,* Philocheras trispinosus *on the sandy bottom, and* Palaemon elegans *in the biocenosis of coarse sands and gravels. Altogether, 14 benthic decapod species have been found.*

Key words: decapod fauna, littoral, sedimentary bottom, northern Adriatic

STUDIO PRELIMINARE DELLA FAUNA A DECAPODI DI FONDO SEDIMENTARIO NELL'INFRALITORALE SUPERIORE DELL'ISOLA DI VEGLIA (MARE ADRIATICO)

SINTESI

La prima stesura della Lista di riferimento degli habitat meritevoli di salvaguardia del Piano d'Azione per il Mediterraneo dell'UNEP comprende i fondi sedimentari delle biocenosi infralitorali. Tali habitat sono molto rari lungo la costa orientale dell'Adriatico. Uno studio è stato pertanto eseguito sulla fauna a decapodi raccolta con l'ausilio di una rete da spiaggia nell'infralitorale superiore (profondità compresa tra 0 e 1 m) su tre spiagge dell'isola di Veglia (Adriatico settentrionale). Ogni località è caratterizzata da un diverso tipo di substrato sedimentario (fango, sabbia, ghiaia). La composizione in specie, la loro abbondanza e dominanza vengono presentate per ogni località, come pure uno studio comparativo tra di esse. Ogni località ha una propria specifica specie dominante. Carcinus aestuarii *è la specie dominante su fondo fangoso,* Philocheras trispinosus *su fondo sabbioso e* Palaemon elegans *nella biocenosi di sabbie grossolane e ghiaie. In totale sono state trovate 14 specie di decapodi bentonici.*

Parole chiave: fauna a decapodi, litorale, fondo sedimentario, Adriatico settentrionale

INTRODUCTION

The research on decapods in the Adriatic began in the 19th century (Ševčić, 1993). In 1918, O. Pesta integrated all knowledge hitherto acquired in his monograph *Die Decapoden Fauna der Adria*. That was the actual beginning of intensive submarine research along the Adriatic coast. Within the systematic expeditions, decapods were researched as well. In the northern Adriatic, the research was mainly conducted along the Istrian coast (Manning & Ševčić, 1982; Ševčić, 1991), and the Kvarner islands (Ševčić, 1979; Gamulin-Brida *et al.*, 1980). The research generated new knowledge on the composition of the crustacean population in the muddy bottom biocenoses of the lower infralittoral and circalittoral (Gamulin-Brida *et al.*, 1972), and of the rocky mediolittoral and infralittoral (Pérès & Gamulin-Brida, 1973). The upper infralittoral of horizontal shores with sedimentary bottom was left open to research. Such areas have not been studied since up to that point the research was mostly conducted by means of trawl nets and bottom grabs drawn by ships. Scuba diving did not produce significant results due to fauna being burrowed in the sediment, well hidden or scared by the movements and bubbles produced by the scuba divers. The UNEP Mediterranean Action Plan Draft Reference List of Habitat Types of Conservation Interest, the title being self-explanatory, is a list drawn up by international scientists under the sponsorship of the UN Environmental Project, in order to protect rare and endangered marine habitats. The list includes sedimentary bottom infralittoral biocenoses as well. Such habitats are very rare on the eastern Adriatic coast. Therefore, an investigation has been carried out to document the decapod fauna collected by means of a beach seine from the upper infralittoral (at a depth of ca. 0-1 m) on three shores of the island of Krk (northern Adriatic). Each locality is characterized by a different kind of sedimentary substrate (mud, sand and gravel). Our intention is to carry out a qualitative analysis in order to prepare a list of species per each locality and to determine their relation to the substratum: whether they are strictly dependent to a certain type of the bottom or have adapted to different types. With a quantitative analysis we wish to determine the frequency of species and their dominance per locality, as well as relative dominance between the localities per species found at more than one station.

MATERIAL AND METHODS

Study area

The decapods recorded here have been sampled at three localities: in Meline cove, St. Marak cove, and Baška cove (Fig. 1). The coves are situated on the southeastern coast of Krk Island.

The localities may be described as follows:

- Meline (kr1) is a relatively large cove, sheltered from northern and southern winds. The maximum depth in the middle of the cove reaches about 3 m, increasing gradually to 6 m at the cove entrance. The substrate is muddy sand. In the mediolittoral zone, the biocoenosis of superficial muddy sands in sheltered waters has developed. In the sediment, the bivalve *Cerastoderma edule* prevails. In the infralittoral, too, predominates the biocoenosis of superficial muddy sands in sheltered waters with communities of *Cymodocea nodosa*. The fauna is very rich in forms, composed of fishes, crustaceans, snails, bivalves, etc. The stream periodically flowing into the cove has a minor influence on the water quality. Sewage systems of the towns surrounding the cove (Klimno, Čižići, Dobrinj) may have a greater influence.

- St. Marak (kr2) is a small cove, poorly sheltered from the waves and winds. The cove ends in the beach, which is somewhat better protected by the breakwater of the nearby port. The substrate is fine sand. Up to 0.5 m in depth predominates the biocoenosis of superficial sands in very shallow waters with bare bottom and endobionts' holes. Boulder stones are overgrown by algae *Acetabularia acetabulum* and *Cladophora* sp. In the eastern part of the cove, at a depth of 1.5 m, rocky bottom prevails, with pure sand between the rocks. A community of photophilic algae with low thalli has developed here. The predominant species here are: green alga *A. acetabulum*, brown algae *Dictyota linearis* and *Dictyota dichotoma*, and red alga *Laurentia obtusa*. Small thalli of the alga *Padina pavonica* and smaller settlements of the alga *Dasycladus vermicularis* were observed. Recently washed away shells of the bivalves *Acanthocardia tuberculata, Callista chione* and *Paphia aurea* are common on the sandy bottom. On the sandy bottom off the cove's western shore, at a depth of 2 m, biocoenosis of superficial muddy sands in sheltered waters with a meadow of *C. nodosa* has developed. The nearest town (Risika) is a few kilometres away.

- Baška (kr3) is a bay, with gravel beach at its far end. The gravel substrate extends to a depth of 1 m. The bottom is bare, with a low bed of alga *Cladophora* sp. within the biocoenosis of coarse sands and fine gravels mixed by the waves. Further into the bay, there are boulder stones with thick settlements of the bivalves *Mytilus galloprovincialis* and *Ostrea edulis*. The rocky bottom is covered by a mossy layer of alga *Cladophora* sp., and to a lesser degree by algae *Peyssonnelia* sp. and *Ceramium rubrum*. In the area exceeding the depth of 2 m prevails the biocoenosis of superficial sands in very shallow waters. At the sampling point, the rivulet Ričina flows into the sea. As the town of Baška and its campground are situated close to the beach, the anthropogenic influence on the water quality could be considerable, especially in the summer period.

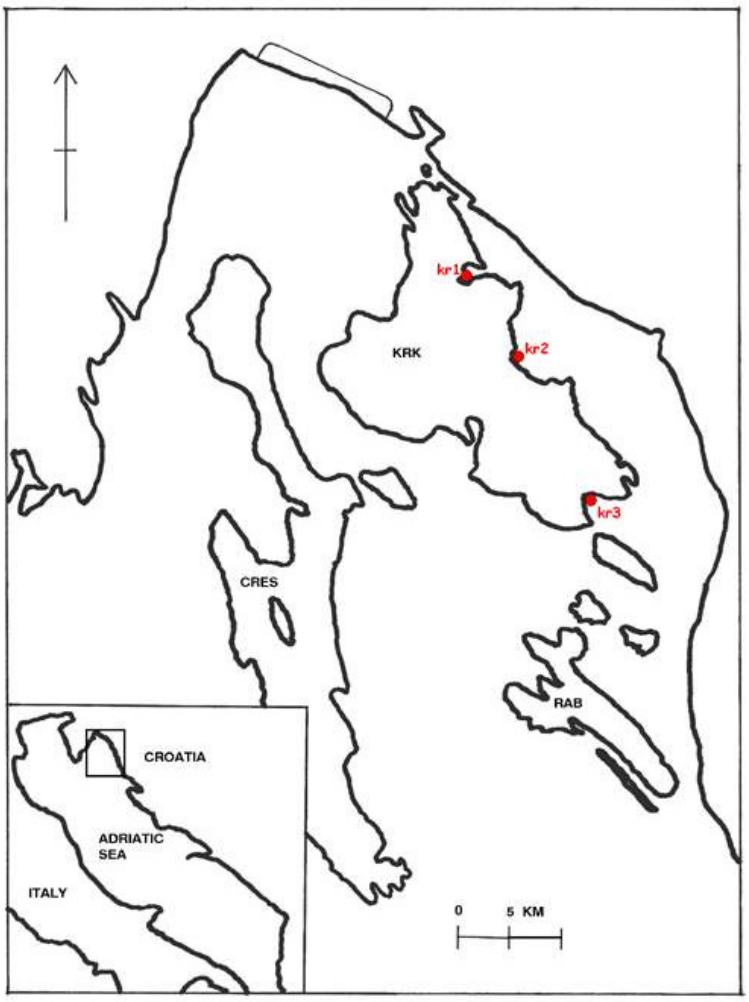

Fig. 1: Study area.
Sl. 1: Raziskovano območje.

Material and methods

The material was collected in the mornings, in March 2002, once per each station, by means of a beach seine (Gibson *et al.*, 1993). Trawl hauls lasted for approximately 1 min and covered a mean distance of about 50 meters per each station. The seine net had 6 mm meshes. Its sides were 5 m long, it was 0.8 m high, its sack 1 m deep. The seine sampled animals of all sizes: from 10 cm long *Carcinus aestuarii* specimens to only few mm long specimens of *Athanas nitescens*. Apart from the decapods, the catch included some diverse fishes (Gobiidae, Sparidae, Soleidae, Callionymidae...). At the locality kr1, the seine was drawn perpendicularly to the shore from the depth of 1 m. At the locality kr2, it was drawn perpendicularly to the shore, from the depth of 1.5 m to the shore. Due to bottom configuration at the locality kr3, the seine was drawn horizontally to the shore covering the bottom up to the depth of 1 m. The decapods were separated in the field and preserved in 5% formol solution, to be analysed and counted in the laboratory. The species composition, their abundance and dominance were given for each locality, upon which a comparative study was conducted.

RESULTS AND DISCUSSION

The research revealed 14 decapod species at the three investigated localities. Each locality exhibits different species composition and different dominant species. The results are given in Tables 1, 2 and 3, listing the number of specimens and percentages of species per locality.

Table 1 lists six species found in the seine at kr1 locality. It is evident that *C. aestuarii* is the dominant decapod, its share in the catch being 72.50%. This species lives in the intertidal and sublittoral zone, on every kind of soft bottom, frequently nearby estuaries and lagoons

(Falciai & Minervini, 1992). *Upogebia pusilla* is also very common in this kind of environment. It lives in burrows 20 cm deep and is probably very hard to catch with seine net. *Diogenes pugilator* is a preferential characteristic hermit crab species of the well-sorted fine sands (Pérès & Picard, 1964). *Palaemon adspersus* lives on muddy sediment near sea grass meadows in brackish waters (Falciai & Minervini, 1992).

Tab. 1: Decapods collected at kr1 locality (Meline cove).
Tab. 1: Deseteronožci, ujeti na lokaliteti kr1 (draga Meline).

Species	No. specimens	%
Palaemon adspersus	2	2.50
Crangon crangon	16	20.00
Upogebia pusilla	2	2.50
Diogenes pugilator	1	1.25
Carcinus aestuarii	58	72.50
Macropodia rostrata	1	1.25

Furthermore, *Crangon crangon* is the only species with more than two specimens in the catch. This species is also frequent at the river mouths and/or lagoons. It lives in the burrows and exits during the night (Falciai & Minervini, 1992).

Tab. 2: Decapods collected at the kr2 locality (St. Marak cove).
Tab. 2: Deseteronožci, ujeti na lokaliteti kr2 (draga Sv. Maraka).

Species	No. specimens	%
Athanas nitescens	2	3.23
Palaemon elegans	14	22.58
Philocheras trispinosus	33	53.23
Clibanarius erythropus	3	4.84
Pisidia longicornis	3	4.84
Porcellana platycheles	1	1.61
Xantho poressa	4	6.45
Liocarcinus depurator	1	1.61
Macropodia rostrata	1	1.61

St. Marak beach (Tab. 2) appears to be the locality with most diversified decapod population, where 9 different species of decapod crustaceans were found. *Philocheras trispinosus*, pursuant to the Adriatic decapod check-list (Ševčić, 1990) and a rare species in the Adriatic, appears to be fairly common at this station. It is the dominant species, its share in the catch being 53.23 %. *Palaemon elegans* is quite abundant on this beach as well, with the share of 22.58%. *P. adspersus* lives on muddy sediment near sea grass meadows in brackish waters (Falciai & Minervini, 1992*). Macropodia rostrata* is also very common in a few meters on mixed sediments (Falciai & Minervini, 1992).

Table 3 demonstrates almost absolute dominancy of the species *P. elegans*, its share in the upper infralittoral of Baška beach being 97.18%. As opposed to the "dominant" shrimps *P. trispinosus* and *P. elegans*, the crab *C. aestuarii* has been found on the muddy bottom of the Meline cove beach only. *C. aestuarii* appears to be more dependent on the substrate of its habitat than the two other species. The environment of Meline cove seems to be suitable for the species listed above (apart from *D. pugilator* and *M. rostrata)*. The relative abundances are probably strictly related to the catching method utilized for the research.

Tab. 3: Decapods collected at the kr3 locality (Baška bay).
Tab. 3: Deseteronožci, ujeti na lokaliteti kr3 (zaliv Baška).

Species	No. specimens	%
Palaemon elegans	69	97.18
Philocheras trispinosus	2	2.82

As far as other study sites are concerned, species like *Clibanarius erythropus, Pisidia longicornis, Porcellana platycheles* and *Xantho poressa* are normally found close to the stones or pebbles on the sandy bottom. In this case, too, their relative abundances are due to the catching method.

The species *P. elegans* and *P. trispinosus* were found at the sandy locality kr2, as well as in the biocenoses of coarse sands and gravels at locality kr3. *Macropodia rostrata* was found on the muddy bottom at the Meline cove station, and in the sandy infralittoral of St. Marak beach. These are the only three species caught on more than one type of substrate. The data reveals that *P. elegans* prefers coarse sedimentary bottom to sandy bottom and does not appear on muddy substrate at all. As opposed to *P. elegans*, *P. trispinosus* prefers sandy bottom to gravel and does not appear on muddy substrate. *M. rostrata* sporadically appears in the biocoenosis of superficial muddy sands in sheltered waters, yet it never inhabits coarse sedimentary substrate.

For the other listed species, not enough specimens were collected at the three localities to enable us to positively establish their exclusive connection with the type of habitat substrate.

CONCLUSIONS

The figure of 14 collected decapods is a relatively good result considering the number of times the beach seine was drawn. In comparison with the results of decapod collection nearby, at 25 stations along the southwestern coast of Krk Island at depths of 2-30 m (Gamu-

lin-Brida *et al.*, 1980), where 16 species were caught, it in fact appears to be even better. The species *C. aestuarii* is dominant on the muddy bottom of the researched locality, *P. trispinosus* is dominant on the sandy bottom, and while *P. elegans* is dominant on the coarse bottom. The crab *C. aestuarii* was found exclusively on the muddy substratum. Decapods *P. elegans* and *P. trispinosus* do not depend on only one type of bottom substrata.

The acquired data on the dominancy of decapod species in specific sedimentary habitats, and their dependence on those habitats should be supplemented with data per season, and data on night time beach seine drawing at the above-mentioned localities. Drawing the seine in every season would determine possible annual vertical migrations and changes in the decapod composition. Additional night time sampling would eliminate the shortcomings of the daily sampling resulting from certain species being covered up or inactive at daytime.

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PREDHODNA RAZISKAVA FAVNE DESETERONOŽCEV NA SEDIMENTNEM DNU V ZGORNJEM INFRALITORALU OTOKA KRKA (JADRANSKO MORJE)

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POVZETEK

Osnutek referenčnega seznama habitatnih tipov varstvene pozornosti, pripravljen v okviru akcijskega načrta okoljskega programa Združenih narodov (UNEP), vključuje tudi sedimentne biocenoze spodnjega infralitorala. Zaradi dejstva, da so takšni habitati zelo redki vzdolž jadranske obale, je bila napravljena raziskava favne deseteronožcev, in sicer ob pomoči mrež s plovci v zgornjem infralitoralu (v globini od 0 do 1 m) na treh obrežnih odsekih otoka Krka. Za vsako od teh treh lokalitet je značilna specifična sedimentna podlaga (glen, pesek, prod). Na vsaki lokaliteti je bila ugotovljena sestava vrst, njihova številčnost in prevlada, in na osnovi teh ugotovitev napravljena primerjalna študija. Vsaka raziskana lokaliteta ima svojo specifično prevladujočo vrsto: Carcinus aestuarii *prevladuje na glenastem dnu,* Philocheras trispinosus *na peščenem,* Palaemon elegans *pa v biocenozi grobega peska in proda. Skupaj je bilo zabeleženih 14 bentoških dekapodnih vrst.*

Ključne besede: favna deseteronožcev, litoral, sedimentno dno, severni Jadran

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BRAZDASTI KIT *(BALAENOPTERA PHYSALUS)* V PRIRODOSLOVNEM MUZEJU SLOVENIJE

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IZVLEČEK

Dne 10. marca 2003 je bilo v Piranskem zalivu najdeno 13,2 m dolgo truplo samice že razpadajočega brazdastega kita. Ker je Prirodoslovni muzej Slovenije (PMS) izrazil interes, da pridobi okostje, sta Ministrstvo za okolje, prostor in energijo in Ministrstvo za promet in zveze izdali odločbi, s katerima sta dovolili potop trupla ob izlivu piranske kanalizacije v globini 20 m. Potapljaška ekipa je truplo spravila v mrežo, ga prepeljala na mesto potopa, obtežila z betonskimi bloki in potopila na dno. Po oceni potapljačev, ki so truplo pregledovali vsak mesec, razkroj ni imel kvarnega vpliva na okolico. Razkroj, ki je bil večinoma bakterijski, je hitro napredoval, zato so potapljači in uslužbenci PMS 7. julija 2003 dvignili spodnji čeljustnici. Ker je bilo v predelu spodnječeljustnične glave še vedno veliko razpadajočega tkiva, se je PMS odločil, da dvig preostalega skeleta preloži v leto 2004.

Ključne besede: brazdasti kit, *Balaenoptera physalus*, razkroj, Prirodoslovni muzej Slovenije, pravni vidiki, Slovenija

LA BALENOTTERA COMUNE *(BALAENOPTERA PHYSALUS)* AL MUSEO DI SCIENZE NATURALI DELLA SLOVENIA

SINTESI

Il 10 marzo del 2003 è stato rinvenuto nel Golfo di Pirano il corpo in decomposizione di un esemplare femmina di balenottera comune, della lunghezza di 13,2 metri. Il Museo di Scienze Naturali della Slovenia ne ha richiesto lo scheletro, perciò il Ministero per l'ambiente, il territorio e l'energia e quello per i trasporti ed i collegamenti hanno emesso una disposizione con la quale si autorizzava l'affondamento del cadavere, ad una profondità di 20 metri, nei pressi dello scarico a mare della rete fognaria di Pirano. Una squadra di sommozzatori ha avviluppato il cadavere in una rete, l'ha trasportato sul luogo prescelto, l'ha zavorrato con blocchi di cemento e l'ha fatto sprofondare sul fondo. Secondo i subacquei, che mensilmente ispezionavano il corpo, la decomposizione non ha avuto conseguenze negative sull'ambiente circostante. La decomposizione, soprattutto batteriologica, ha avuto un decorso rapido, perciò il 7 luglio 2003 i sommozzatori e gli esperti del Museo hanno tratto dal mare i rami mandibolari inferiori. Poiché la parte inferiore del cranio presentava ancora molto tessuto in decomposizione, il Museo ha deciso di rimandare al 2004 il recupero del resto dello scheletro.

Parole chiave: balenottera comune, *Balaenoptera physalus*, decomposizione, Museo di Scienze Naturali della Slovenia, aspetti legali, Slovenia

UVOD

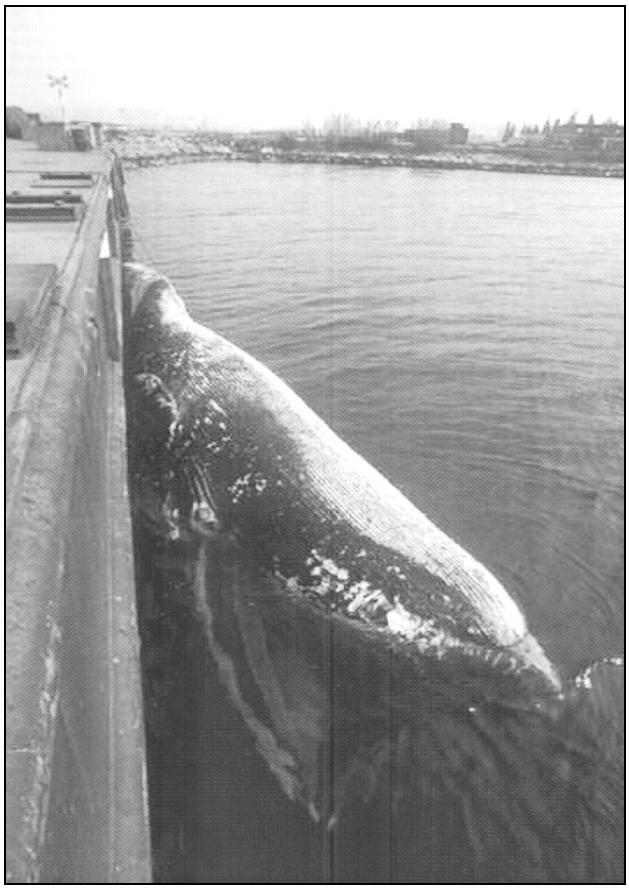
Material kitov, ki ga hrani Prirodoslovni muzej Slovenije (PMS), je več kot skromen. Leta 1954 je PMS od prof. Vinka Žitnika z ljubljanske vajeniške šole dobil vretence 18 m dolgega kita, ki je nasedel l. 1914 pri Vinjereu, Starigrad, Paklenica (Hrvaška). Verjetno gre za brazdastega kita *(Balaenoptera physalus).* Tri leta pozneje (1957) je Muzej za tedanjih 900 dinarjev v ljubljanski ribarnici kupil navadnega delfina *(Delphinus delphis).* Kot datum je v inventarni knjigi vpisan 11. junij 1957, kot nahajališče pa se navaja samo "Jadran". Muzej že najmanj 25 let tega preparata ne hrani več. Dne 6. maja 1962 je PMS od Ribiške zadruge Strunjan kupil primerek velike pliskavke *(Tursiops truncatus),* ki je bil vse do nedavnega razstavljen kot dermoplastični preparat. Celotna dolžina preparata je merila 256 cm. Sredi 90-ih let preteklega stoletja se je tedanje muzejsko vodstvo odločilo, da preparat odstrani. Po vztrajanju strokovne službe je naposled privolilo, da se preparat ohrani kot odlitek in da se pred uničenjem odstrani lobanja. Odlitek je danes razstavljen (fotografijo izvirne dermoplastike sta objavila Kryštufek & Lipej, 1993), lobanja pa je shranjena v študijski zbirki PMS. Drug primerek v PMS je lobanja 225 cm dolge velike pliskavke, ki jo je 29. septembra 1991 naplavilo v Bešaniji pri Savudriji. Zaradi nestrokovnega prepariranja so izpadli vsi zobje. Fotografijo lobanje sta prav tako objavila Kryštufek & Lipej (1993).

V zadnjih dveh letih si je PMS prizadeval, da bi pridobil okostje velike pliskavke, najpogostejšega delfina v severnem Jadranu. Kljub razmeroma pogostim najdbam mrtvih primerkov ob slovenski obali so se sprva porajale težave z veterinarsko službo. Po Uredbi o zavarovanju ogroženih živalskih vrst (Ur. l. RS št. 57, 14. X. 1993) je najditelj mrtvih sesalcev ali ptičev zavarovanih vrst (mednje sodijo tudi vsi kiti) dolžan o najdbi obvestiti pristojno veterinarsko službo, katere dolžnost pa je, da strokovnim delavcem PMS omogoči sodelovanje pri strokovnem delu in prevzem trupel. Določila Uredbe so se vse od njenega sprejetja v praksi bolj malo upoštevala, veterinarska služba pa je takšen material po preiskavi praviloma namenila sežigu. Tako smo v letih 2002/03 izgubili primerek velike pliskavke in s precejšnjo težavo pridobili drugega, ki pa je zaradi mladosti manj primeren za skeletiranje. Zadnji primerek je bil najden 19. januarja 2003 pri Strunjanu. Težak je bil 90–100 kg, v dolžino pa je meril 191 cm.

KIT V PIRANSKEM ZALIVU

Dne 10. marca 2003 je PMS prejel obvestilo, da so Piranskem zalivu odkrili truplo brazdastega kita (Sl. 1), za katerega je bilo ocenjeno, da je dolgo *"okoli dvanajst metrov in tehta vsaj štiri tone"* (Šuligoj, 2003a). Kasnejše meritve so pokazale, da je žival dolga 13,2 m, repna plavut široka 3,2 m in prsna plavut dolga 1,55 m. Truplo, na katerem so bili že opazni sledovi razpadanja, je Služba za varovanje obalnega morja pri Agenciji RS za okolje (Ministrstvo za okolje, prostor in energijo – MOPE) prepeljala v koprsko luko. PMS se je takoj po prejemu obvestila (približno ob 12. uri istega dne) povezal z Veterinarsko fakulteto Univerze v Ljubljani in izrazil interes, da po veterinarskih pregledih prevzame žival in jo skeletira. V naglici smo že v ponedeljek, 20. marca, sestavili načrt skeletiranja. Ob približno 14. uri sta bila dva uslužbenca PMS pripravljena, da odpotujeta v Koper in organizirata delo. Zavedali smo se, da skeletiranja tako velike živali ne moremo opraviti v stavbi PMS na Prešernovi 20, zato smo kot edino možnost predvideli njeno potopitev in razkroj na morskem dnu. V teku prvega dne se veterinarska služba ni odločila, kaj bo s truplom naredila. Kot najverjetnejšo možnost so navajali prepolovitev živali in njen prevoz v posebej prilagojenem vozilu v secirnico Veterinarske fakultete Univerze v Ljubljani. V tem primeru bi bil primerek za PMS verjetno izgubljen. Torek 21. marca je minil v nenehnih pogovorih s štirimi ministrstvi (Ministrvo za kmetijstvo, gozdarstvo in prehrano, MOPE, Ministrstvo za zdravstvo in Ministrstvo za promet). Zaradi številnih zapletov se je vodstvo PMS proti koncu delovnega dne obrnilo na Ministrstvo za kulturo (MK) s prošnjo za posredovanje. To, in pa podpora MOPE, sta proti koncu dneva prevesila jeziček na tehtnici v smeri rešitve, ugodne za PMS. MOPE je zavzel stališče, da mrtvi brazdasti kit ni odpadek v smislu določil Protokola o preprečevanju onesnaževanja Sredozemskega morja (Ur. l. SFRJ – MP, št. 12/77 in Ur. l. RS 102/02 – MP), ampak del biomase, ki leži v morju in se razgrajuje v svojem življenjskem okolju. Takšna interpretacija zakonskih določil je bila ključnega pomena za nadaljnji razplet dogodkov. Istega dne je tudi Ministrstvo za promet, ki je pristojno za izdajo dovoljenj za vse dejavnosti na morju, dovolilo potop živali na območju izlitja piranske kanalizacije. V sredo dopoldne se je PMS dogovoril z izvajalcem del Ugom Fondo, univ. dipl. biol., samostojnim podjetnikom, da pripravi vse potrebno za potopitev živali. Po načrtu je bilo treba sešiti mrežasto vrečo (velikost okenc 15 mm) in vanjo spraviti celo žival, kar bi preprečilo kasnejšo izgubo manjših kosti (Sl. 2). To delo je trajalo vse do petka, ko je zapihala burja in preprečila prevoz na kraj potopitve. V soboto je izvajalec prepeljal kita do Pirana in ga privezal na plovec pred Morsko biološko postajo. Vetrovno vreme se je nadaljevalo tudi v nedeljo, tako da je izvajalec truplo lahko potopil šele v ponedeljek, 17. marca, teden dni po tem, ko so ga tokovi zanesli v Piranski zaliv. Potek del sta opisala tudi izvajalec (Fonda, 2003) in snemalec PMS, ki je dela fotografsko dokumentiral (Mlinar, 2003).

Vsi dogodki so pritegnili izjemno pozornost medijev, o njih pa so dnevno poročali TV Slovenija, POP TV, nekatere radijske postaje in dnevniki (Delo, Večer, Dnevnik, Primorske novice, Slovenske novice, Gorenjski glas). Ni manjkalo tudi očitkov zaradi počasnih del:



Sl. 1: Samica brazdastega kita, najdena 10. marca 2003 v Piranskem zalivu. Truplo je privezano k pomolu koprske luke. (Foto: C. Mlinar)
Fig. 1: Carcass of the female fin whale found in the Bay of Piran on March 10, 2003. The carcass is tied to a pier in the Port of Koper. (Photo: C. Mlinar)

"Stroka ne ve, kako ravnati s poginulim kitom" (Dnevnik, sreda 12. marca 2003, leto LIII, št. 68, str. 11) in *"Kitovka smrdi od sramu"* (Slovenske novice, sreda 12. marca 2003, leto XIII, št. 58, str. 2). Administrativno reševanje je vzelo dva dni časa, sama izvedba del nadaljnja dva dneva, trije dnevi pa so bili izgubljeni zaradi slabega vremena. Zapleti na administrativni ravni so v veliki meri razumljivi, če upoštevamo izjemnost in enkratnost dogodka. S takšno problematiko nima izkušenj nobeden od državnih resorjev, primanjkovalo pa je tudi informacij. Na splošno pa je bilo na vseh nivojih veliko razumevanja in pripravljenosti, da se stvari uredijo na razumen in sprejemljiv način. Bile so sicer tudi izjeme, ki pa so bile resnično izjemne.

OZADJE

"Jadransko morje je le majhen, plitev zaliv Sredozemskega morja, to pa je spet samo majhen in plitev zaliv oceana. Tako utesnjene vode zagotavljajo ugodne življenjske razmere edinole pliskavkam, medtem ko velike vrste kitov (v prvi vrsti vosati kiti) zaidejo k nam res izjemoma. Zdi se nam, da se za živali neomejenih oceanskih prostranstev takšna pot rada konča nesrečno, saj jih po prehodu Otrantskih vrat čakajo številne zahrbtne plitvine, kjer nasedejo." (Kryštufek & Lipej, 1985).

Za Sredozemsko morje je za zdaj znanih 22 vrst kitov (od skupno 78). Navedbe za štiri vrste so dvomljive, tako da je nedvoumno dokazano pojavljanje 18 vrst, od katerih so samo štiri vrste vosatih kitov (Kryštufek & Lipej, 1993). Od vosatih kitov se redno pojavlja edinole brazdasti ali hrbtopluti kit *(B. physalus),* zajval *(Balaenoptera borealis)* in ščukasti kit *(Balaenoptera acutorostrata)* se pojavljata redko, biskajski kit *(Eubalaena glacialis)* pa je naključna vrsta. Po tradicionalni razlagi je za Sredozemlje namreč značilna nizka primarna produkcija, zato ni privlačno za vosate kite, ki se prehranjujejo s precejanjem planktona. Kot bo razvidno kasneje, ta teorija očitno ni splošno veljavna.

Brazdasti kit je ena največjih živalskih vrst. Odrasla žival zraste v dolžino 18 do 25 m in tehta približno 80 ton; samice so nekoliko večje od samcev. Živali, ki živijo v Sredozemlju, merijo v povprečju 13,8 m, najdaljša zabeležena dolžina (25,6 m) pa ni zanesljiva (Notarbartolo di Sciara *et al.*, 2003). Sredozemske samice (14,7 m) so v povprečju nekoliko daljše od samcev (13,4 m), vendar razlika ni statistično značilna (Notarbartolo di Sciara *et al.*, 2003). Mladič je dolg 5,5–6 m in tehta 2 t; ocenjena dolžina novorojencev v Sredozemlju je 5,2 m. Nizka hrbtna plavut je na zadnji tretjini telesa. Na grlu so številne vzporedno potekajoče brazde. Hrbet je siv, trebuh bel, obarvanost glave pa ni simetrična. Nesomernost je očitna na spodnji in zgornji ustnici ter v vrhnji tretjini vosov (beli ali svetlo sivi na desni strani in temni na levi strani), v belkastem madežu na desni strani glave in v listi v obliki črke V za nosnico (navadno svetlejša na desni strani). V zgornji čeljusti je 520–946 rumenkastih vosov, ki so dolgi do 90 cm, navadno pa merijo 60 cm; široki so do 30 cm. Lobanja je dolga 4,3 do 4,6 m. Brazdasti kit je kozmopolit, obsega pa dve podvrsti, ki se razlikujeta v velikosti in morfologiji vretenc; *B. p. physalus* živi na severni polobli, *B. p. quoyi* pa na južni (Notarbartolo di Sciara *et al.*, 2003). Poleti plava v hladne vode, pozimi pa v tople, vendar sezonske migracije niso močno izražene. Po oceni jih živi 120.000 (večina v Pacifiku); na severni polobli jih je samo 20.000. Sredozemska populacija, ocenjena na 3.500 osebkov, je zanesljiva (Notarbartolo di Sciara *et al.*, 2003). V začetku stoletja so vrsto v Sredozemlju komercialno lovili. Začetki kitolova v Gibraltarskem prelivu segajo v leto 1921. Po statistikah je bilo v letih 1921–1927 ob španskih obalah (največ v območju Gibraltarja) ubitih kar 6.250 velikih kitov, od katerih jih je bilo več kot 90% brazdastih (Viale, 1985). Kitolov se je obdržal vse do 80-ih let prejšnjega stoletja, kar je močno vplivalo na populacijo brazdastega kita v Sredozemlju; v

Sl. 2: Ekipa Uga Fonde v koprski luki ovija brazdastega kita v mrežasto vrečo. (Foto: C. Mlinar)
Fig. 2: Ugo Fonda's team in the Port of Koper, wrapping the fin whale in a meshed sack. (Photo: C. Mlinar)

območju Gibraltarskih vrat je vrsta od 60-ih let prejšnjega stoletja iztrebljena.

Domneve o endemičnem statusu sredozemske populacije brazdastega kita segajo že v začetek 19. stoletja, ko so mu avtorji celo priznavali taksonomski status endemične vrste (pod imeni *B. rorqual, B. mediterraneus, B. antiquorum* ali *B. aragonus)*. Ob koncu 19. stoletja je norveški zoolog Geor O. Sars na osnovi ekoloških opažanj trdil, da je sredozemska populacija izolirana, novejše molekularno-biološke raziskave mitohondrialne in jedrne DNK pa so to potrdile (Notarbartolo di Sciara *et al.*, 2003). V Sredozemlju je brazdasti kit verjetno že tisočletja najpogostejši vosati kit, saj ga omenjajo že nekateri antični pisci (Aristotel, Plinij). Razširjenost vrste v bazenu ni enakomerna, daleč največja zgostitev (73,8% vseh opažanj; Notarbartolo di Sciara *et al.*, 2003) pa je v trikotniku, ki ga tvorijo južna obala Francije in zahodna obala Korzike in Sardinije. V Egejskem morju in v levantinskem bazenu je vrsta zelo redka (približno 1% vseh sredozemskih opažanj), v Marmornem in Črnem morju pa je sploh ni. V Jadran, kjer je vrsta razmeroma redka (1,4% opažanj), zaidejo posamezni klateški osebki iz Jonskega morja in osrednjega Sredozemlja. Brazdasti kit je namreč izrazito pelagična vrsta, ki le redko plava v morju, plitvejšem od 1000 m. Zato ne preseneča, da njegova številčnost v Jadranu proti severu hitro upada. Velike zgostitve ob francoski obali so posledica velike primarne produkcije, posledica primarne produkcije pa namnožitev svetlečih kozic *Meganyctiphantes norvegica* v poletnih mesecih, ki so kitova osnovna hrana. V času razmnoževanja se kiti razkropijo. Večina skotov je med septembrom in januarjem, predvsem pa novembra.

Kot rečeno, se brazdasti kit pojavlja v Jadranskem morju razmeroma redko, še redkeje pa zaide v severni Jadran. Leta 1831 je bil najden mrtev primerek pri Miljah (Brusina, 1888), 22. junija 1976 pa je v tržaškem pristanišču nasedla samica, dolga 9,8 m in težka 4 tone. Od 6. do 8. junija 1979 so v delti reke Pad opazovali samico z mladičem. Šest ribiških ladij je tedaj preprečilo, da bi kita nasedla, in ju nato usmerilo v globlje vode, 20 milj od obale (Rallo, 1979). Di Natale & Mangano (1983) navajata opažanja v severnem Jadranu tudi v letih 1978–1982.

Brazdasti kit je ena od šestih vrst kitov, zabeleženih v Jadranu, severno od 45. vzporednika. Od drugih vrst so štirje delfini (navadni delfin, velika pliskavka, progasti delfin *Stenella coeruleoalba* in okrogloglavi delfin *Grampus griseus*) in glavač *Physeter catodon* (Kryštufek & Lipej, 1993). Podatki o veliki pliskavki so najpogostejši, za vse druge vrste pa redki ali izjemni. Posebej velja omeniti 12,4 m dolgega glavača, ki je 1. junija 1555 nasedel v močvirju Fontanigge v Sečoveljskih solinah (Kryštufek & Lipej, 1985).

Dnevni tisk je 3. januarja 2003 poročal o brazdastem kitu, dolgem *"kakih 15 metrov"*, ki je *"minule dni plaval"* ob slovenski obali (Šuligoj, 2003b). Glede na redkost pojavljanja te vrste v severnem Jadranu je povsem mogoče, da gre za isto žival, ki smo jo slaba dva meseca kasneje našli mrtvo v Piranskem zalivu. Vzrok smrti ni znan. Omenimo, da samica, najdena 22. junija 1976 (glej zgoraj) ni kazala znakov zastrupitve. Princi & Bussani (1976) sta določevala vsebnost živega srebra v krvi, vranici, pljučih, črevesju, jetrih in iztrebkih ter ugotovila, da je pod mejo kontaminacije, določeno za morska živila.

PRAVNI STATUS BRAZDASTEGA KITA

Uredba o zavarovanju ogroženih živalskih vrst (1993) uvršča na seznam tudi vse vrste kitov. Kot ustanovo v Republiki Sloveniji, pooblaščeno za prevzem in hranjenje živali z omenjenega seznama, uredba navaja edino PMS.

Dne 13. marca 2003 je Občina Piran naslovila na PMS dopis za pridobitev okostja najdenega kita. Interes je utemeljevala z dejstvom, da je bil kit najden v Pi-

ranskem zalivu, njegovo okostje pa bi bilo lahko razstavljeno v prenovljeni stavbi Morske biološke postaje. Takšna krajevna posebnost in atrakcija bi tudi vidno obogatili turistično ponudbo kraja. Kot možna kraja na slovenski obali, kjer bi bilo lahko razstavljeno okostje, sta se kasneje omenjala tudi Piranski akvarij in pa načrtovani ribiški muzej. Čeprav so mediji o tej pobudi objektivno poročali (npr. Hlaj, 2003), se je v javnosti ustvaril vtis, da *"'lastništvo' mrtvega kita ni znano"*. MK je zato kot pogoj za dodeljevanje dodatnih finančnih sredstev za skeletiranje kita navajalo ureditev pravnih vidikov. PMS se je 18. marca obrnil na MOPE s prošnjo za tolmačenje Uredbe o zavarovanju ogroženih živalskih vrst. MOPE je v dopisu št. 354–09–772003 z dne 7. aprila posredovalo sledeče stališče: *"Z Uredbo o zavarovanju ogroženih živalskih vrst so določena pravila ravnanja z osebki zavarovanih vrst, vključno z mrtvimi. Namen določitve ravnanja z mrtvimi osebki je bil omogočiti znanstveno in muzejsko delo z živalmi, ki jih je sicer zaradi varstvenega režima težko pridobiti. … S sprejemom uredbe je bila naloga v zvezi z ravnanjem z mrtvimi živalmi zavarovanih vrst dana Prirodoslovnemu muzeju Slovenije in sicer iz razloga, ker je osrednja nacionalna naravoslovna muzejska inštitucija, pooblaščena za strokovno obdelavo in hranjenje eksponatov, obenem pa tudi omogoča dostop do materiala drugim znanstveno-raziskovalnim inštitucijam. Nenazadnje je osrednji muzej tudi inštitucija, v kateri je ogled in spoznavanje živali omogočeno širši javnosti. … V desetletni praksi je tako Prirodoslovni muzej prevzemal trupla živali, če je za to izrazil interes, v obratnem primeru so bila trupla uničena v skladu z veterinarskimi predpisi. … Menimo, da je za prevzem trupla oz. okostja zavarovanega brazdastega kita, skladno z uredbo, pristojen Prirodoslovni muzej Slovenije."* Citirani dopis je odstranil pomisleke, tako da je MK odobrilo dodatna sredstva za dela na skeletiranju kita. Podrobnejšo informacijo javnosti je objavil dnevnik "Delo", ki je med drugim zapisal: *"Po uredbi o vzpostavitvi mreže za izvajanje javne službe na področju varstva premične kulturne dediščine in določitvi državnih muzejev je Prirodoslovni muzej Slovenije državni muzej, ki opravlja javno službo – varovanje premične dediščine in matičnost – za tovrstno premično dediščino. Najdba brazdastega kita zagotovo sodi v premično dediščino naravnega izvora, torej je očitno, da primerek sodi edinole v zbirko Prirodoslovnega muzeja"* (Švagelj, 2003).

PREPARIRANJE

Ko je bilo truplo kita najdeno, je že razpadalo, zato je bilo od njega mogoče ohraniti samo okostje. Takšen preparatorski poseg je smiseln, saj skeletni material (predvsem lobanje) tvori večino študijskih zbirk sesalcev. Čeprav mnogi muzeološki priročniki (npr. Nagorsen & Peterson, 1980; Hangay & Dingley, 1985) zelo natančno opisujejo postopke za shranjevanje in preparacijo sesalcev, ne dajejo navodil za živali, večjih od slona *(sic!)*. Omeniti velja, da so v 19. stoletju za Sredozemlje dokumentirani primeri lova vosatih kitov izrecno za potrebe muzejskih zbirk (Notarbartolo di Sciara *et al.*, 2003). Brusina (1888) navaja preprosto metodo, po kateri je skeletiral okrogloglavega delfina, ki ga je leta 1873 dobil v Zadru. Za primerek ne navaja nobenih dimenzij, vrsta pa zraste v dolžino do 4 m in tehta do 700 kg. S trupla je odstranil maščobo in mišičje, prepolovljeno žival pa dal v dve vrši. Dodal je tudi voleke *(Murex* sp.) in vse potopil v morje. Žal ne navaja časa, potrebnega za razkroj. Z rezultati je bil v glavnem zadovoljen. Edina težava je bila v tem, da izvajalec ni natančno upošteval vseh navodil (tako Brusina), zato so se nekatere manjše kosti izgubile.

Zoološki muzej v Zagrebu (danes Hrvaški prirodoslovni muzej) je leta 1990 skeletiral okostje brazdastega kita, nasedlega na otoku Silbi. Kita, ki je bil deloma v vodi, deloma na kopnem, so preprosto prepustili razpadu, po približno letu dni pa pobrali ostanke. Nekaj kosti se je pri tem izgubilo, bodisi da so jih raznesli tokovi ali ljudje, ali pa so izginile iz neznanih vzrokov. Vezivno tkivo in hrustanec nista razpadla, pač pa sta se na zraku posušila. Kosti je bilo treba dodatno kuhati v vodi z dodatkom detergenta. V literaturi je opisana tudi preparacija samice brazdastega kita, dolge 11,5 m in težke približno 7 t, ki so jo ujeli v paški luki (Magerle, 1962). Truplo so *"po nekaj dneh"* prepeljali v Zagreb, kjer so se odločili, da primerek ohranijo kot okostje in kot dermoplastični preparat. Ker muzej ni imel na voljo potrebnih zmogljivosti, jim je prostore odstopila mestna klavnica. Truplo je ležalo na tovornjaku s prikolico, na kateri so ga tudi pripeljali. S pomočjo premičnega ročnega dvigala so najprej dvignili repno plavut in z nje odstranili kožo v dolžini 80–100 cm. Nato so z naslednjim dvigalom dvignili del živali pred plavutjo, ponovili postopek in tako naprej. Trup je ostal na tovornjaku, sproščeno kožo pa so dvignili z dodatnimi dvigali. Dermoplastični preparat so izdelali na muzejskem dvorišču, kjer so postavili delovno mizo površine 12 x 5 m. Kožo so čistili in sproti preparirali z boraksom ter tretirali z arzenikom. Z okostja so mehansko odstranili mišičje in ga nato razstavili na manjše dele. Manjše kosti so najprej izpirali v vodi, jih nato počasi kuhali in naposled prepustili maceraciji. Posamezne kosti so macerirali ločeno, pri čemer so menjali vodo, ki so ji dodali lug. Magerle (1962) navaja, da posebnih težav ni bilo, da pa so bile kosti, svoji velikosti navkljub, vendarle zelo občutljive. Velike skeletne dele (lobanja, večja vretenca, lopatica) so obdelali v velikih lesenih banjah. Počasnemu kuhanju je sledila maceracija. Nazadnje so kosti obelili in razmastili v 2% raztopini luga, s klorovim apnom in bencinom. Zaradi prostorske stiske muzeja je preparat še vedno "začasno" shranjen na podstrešju muzejske stavbe.

Ko je PMS prejel sporočilo o mrtvem brazdastem kitu v Piranskem zalivu, je bila zgornja informacija tudi vse,

kar smo imeli na voljo. Po drugi strani skrajno omejeni čas ni dopuščal veliko manevrskega prostora. Ker je na samem začetku obstajala možnost, da kita prepeljejo v Ljubljano na veterinarske preiskave, smo razmišljali, da bi v tem primeru poginulo žival zakopali. Veterinarski službi se takšna rešitev ni zdela sprejemljiva, tako da za pokop očitno ne bi mogli dobiti dovoljenja. Tako je preostala samo ena možnost: potop. Po posvetovanju z Ugom Fondo smo se odločili, da kita shranimo v vrečo, sešito iz mreže (velikost okenc 15 mm) in potopimo ob izpustih piranske kanalizacije, približno 3,5 km od obale in v globini 22 m. Za premagovanje sile vzgona je bilo truplo treba obtežiti s štirimi tonami betonskih blokov. Pred potopom smo odstranili nekaj vosov, ki so roževinasta struktura, zato morajo biti deležni posebne obdelave. Več mesecev po potopitvi kita sem v londonskem Prirodoslovnem muzeju (Natural History Museum London) izvedel, da v Veliki Britaniji za tak poseg ne bi dobili soglasja. Tamkaj nasedlega kita zakopljejo v pesek na obali. Pa vendar se jim je postopek, ki smo ga izbrali, zdel primeren.

Koliko časa bo truplo ležalo v globini, preden bodo od njega ostale samo kosti, v mesecu marcu še nismo vedeli. Javnost je ta podatek zelo zanimal, večina ugibanj pa je bila med šestimi meseci in dvema letoma. V času pisanja tega prispevka (maj 2004) je truplo že dokončno razpadlo, celotno okostje pa je že na kopnem. Po potopu trupla marca 2003 je PMS usmeril dejavnost na redno mesečno spremljanje procesa dekompozicije, čemur se je posvečal že Ugo Fonda, in na zbiranje potrebne informacije za kasnejše prepariranje in restavriranje.

RAZKROJ KITOVEGA TRUPLA V LETU 2003

Poročilo zajema obdobje od aprila do avgusta 2003. V tem času je ekipa Uga Fonde opravila pet rednih mesečnih ogledov kita. Vsak ogled je izvajalec dokumentiral z video kamero in o tem napisal poročilo. Dokumentacija je shranjena v PMS. Ogledi so bili 21. aprila, 24. maja, 25. junija, 15. julija in 21. avgusta 2003. Aprila je kit ležal na desnem boku na betonskih utežeh, maja pa so se v spodnjem predelu trebušne votline nabrali plini, zaradi česar se je srednji del trupla dvignil od dna in ostal v takšnem stanju tudi junija in julija. Kljub temu da ni obstajala bojazen, da bi truplo splavalo na površje (betonske uteži so še vedno ležale na tleh, vrvi pa so bile obremenjene le z nekaj sto kilogrami sile vzgona), je izvajalec v dodatnem kontrolnem potopu preluknjal trup. Mreža, v katero je truplo zavito, je bila ves čas v brezhibnem stanju.

Temperature morja so razvidne iz Tabele 1. Aprila so bili biološki procesi, ki so osnova razkroja organske snovi, pri nizkih temperaturah temu primerno počasni. Truplo je bilo še vedno kompaktno. Koža je odpadala v kosmih, velikih približno kvadratni centimeter, tako da je bilo že vidno vlaknasto podkožje. Razpad je bil najhitrejši na glavi, vosi pa so že popadali na dno. Vidna sta bila del lobanje in večina spodnje čeljustnice. V maju je koža odpadala v kosmih že pri dotiku. Poleg vlaknastega podkožja je bilo na nekaterih mestih vidno tudi mišično tkivo. Kitova glava je razpadla do te mere, da je bil viden velik del lobanje in zgornje čeljustnice. Spodnji čeljustnici sta bili že povsem vidni, ležali pa sta na lobanji. Tudi desna plavut je že močno razpadla, tako da so bile vidne vse kosti, leva pa je bila še naprej kompaktna. V juniju je razpadanje trupla hitro napredovalo. Koža je že povsem razpadla, na površju pa je bilo vidno mišičje in vezivno tkivo. Lobanja je bila v glavnem že gola, samo v predelu vratu je še ostalo mehko tkivo. Spodnji čeljustnici sta bili že povsem prosti. Desna plavut je v mesecu dni dokončno razpadla, v levi pa so bile vidne kosti. V repnem predelu so se prav tako pokazala vretenca, ki pa so bila med seboj še čvrsto povezana. Julija so bila vsa tkiva, razen hrustanca in tetiv, na otip mehka in so se ob pritisku trgala. Prsni plavuti sta že povsem razpadli, njune kosti pa so ležale v mreži nad tlemi. V bližini repa in v predelu trebuha so bila vidna vretenca, med katerimi so bili še vedno ohranjeni medvretenčni diski. Vosi so začeli vidno propadati in se razkrajati na lamele. Avgusta so od kita ostale skoraj samo še kosti z vezivi in hrustancem. Vzdolž celega hrbta so bila vidna vretenca, med katerimi pa so še vedno ležali diski. Lobanja je bila že povsem očiščena, v vratnem predelu pa je bilo še vedno mehko tkivo. Rebra so že popadala v vrečo.

Tab. 1: Temperature morja (T v ^{o}C) v Piranskem zalivu na površini in v globini približno 20 m, kjer je ležalo truplo brazdastega kita v obdobju april – avgust 2003 (po meritvah Uge Fonda).
Tab. 1: Sea temperature (T in ^{o}C) in the Bay of Piran between April and August 2003. Temperatures are given for the surface and depth of 20 m where the fin whale's carcass was located (based on measurements by Ugo Fonda).

	T (0 m)	T (20 m)
April/April	11,5	10,0
Maj/May	20,0	12,0
Junij/June	25,0	16,0
Julij/July	26,0	16,0
Avgust/August	28,5	18,0

Na truplu, ki so ga v marcu prekrivale bele nitaste strukture, so postajale vse bolj očitne kolonije zajedavskih ceponožcev *Penella balenopterae*. Pod kitom so se zadrževali raki samotarci, ki so ob izlivu kanalizacije mnogoštevilni. Po oceni Uga Fonde je bila večina razkroja mikrobna. V premeru približno 20 m okrog trupla so morske živali (ribe, raki, glavonožci) živele normalno življenje, na mreži, v kateri je potopljeni kit, pa so lignji celo odložili jajčeca. V maju izvajalec ni več opazil kolonij ceponožcev, pod kitom in na njem pa so bili raki samotarci.

Na mrežo pod kitom so lignji v velikem številu odložili jajčeca. Od rib so se pod kitom in ob njem zadrževali številni glavači, okoli njega pa so plavale menule *(Spicara flexuosa)* in druge ribe, ki so se hranile z drobnimi kosmičastimi koščki tkiva. Ribe so tudi trgale koščke mesa z mrtvega kita. V avgustu je pod kitovim truplom ležalo večje število morskih klobas. Tudi v poletnih mesecih je bila večina razkroja še naprej mikrobna. Visoke poletne temperature so vidno pospešile razkroj.

Razkrajajoče se truplo doslej ni kazalo nobenega negativnega vpliva na neposredno okolico. V neposredni bližini trupla so živele ribe (ugor, lep, glavači idr.), raki (samotarci, jastogi) in glavonožci (lignji, sipe in moškatne hobotnice). Enako velja tudi za pritrjene (sesilne) živali. Nekatera bitja so truplo uporabljala kot trdno podlago in skrivališče. To kaže, da je MOPE pravilno ocenilo posledice razpada kitovega trupla v naravnem okolju.

Ker sta bili obe spodnji čeljustnici v juniju že brez vidnega mehkega tkiva, je bil dan predlog, da bi ju dvignili na površje in prepeljali v Ljubljano. Ugo Fonda je namreč izrazil bojazen, da bi ju kdo ukradel. Obe kosti, ki sta se belili na temnem truplu, sta zelo lepega videza, tako da sta bili, kljub svoji velikosti, mamljivi za morebitne zbiralce tovrstnih predmetov. Vodstvo PMS se je odločilo, da predlog sprejme. Obstajala je sicer bojazen, da razpad mehkih tkiv (predvsem kit in hrustanca) v začetnem delu čeljusti še ni končan, kar bi utegnilo povzročati težave pri nadaljnjem prepariranju. Kljub temu je ekipa PMS, skupaj z izvajalcem, 7. julija čeljusti dvignila na čoln. Tudi ta dogodek je pritegnil pozornost medijev (Šuligoj, 2003c; Tanackovič, 2003). Pomisleki so se pokazali za utemeljene. Razkroj v območju spodnječeljustničnega sklepa namreč še ni bil končan (Sl. 3). Izurjena potapljača sta zato drug za drugim delala v globini 23 m celo uro, preden sta kosti ločila od trupa. Razpadajoče mehko tkivo smo na čolnu odstranili. Kosti smo na obali zavili v podloženo plastiko in ju z manjšim tovornjakom prepeljali v Ljubljano. Tu smo ju namestili v plastični bazen in pustili ležati v vodi. Posamezna spodnja čeljustnica je dolga (po obodu) 3,2 m, maso pa ocenjujemo na nekaj manj kot 150 kg. Kljub velikosti je kostno tkivo presenetljivo mehko in krhko. Dne 15. julija je ekipa izvajalcev zašila rez, narejen dober teden pred tem, da so iz mreže potegnili čeljustnici.

Izkušnje, pridobljene ob dviganju spodnjih čeljustnic, so pokazale, da je pri drugih kostnih elementih smiselno počakati do konca razpada. V naslednjem mesecu je zaradi visokih temperatur truplo hitro razpadalo, zato je potapljaška ekipa ocenila, da bo oktobra od živali ostalo samo še okostje. Zaradi izkušenj, pridobljenih ob dvigu spodnjih čeljustnic, se je PMS vendarle odločil, da bo okostje dvignil zgodaj spomladi 2004. Če bi se namreč ob dvigu pokazalo, da razkroj še ni povsem končan, bi to povzročilo veliko težav in dodatnih stroškov. Poleg tega tudi sredstva, ki jih je imel PMS na voljo v letu 2003, niso omogočala obsežnejšega nadaljevanja del.

Sl. 3: Dvig spodnje čeljustnice z morskega dna. V predelu spodnječeljustnične glave je še veliko mehkega tkiva. (Foto: B. Tome)
Fig. 3: Lifting of the lower mandible from the sea floor. The part of articular process still contains much soft tissue. (Photo: B. Tome)

ZAHVALA

Dr. L. Lipeju se zahvaljujem za pripombe k zgodnejši verziji rokopisa.

FIN WHALE *(BALAENOPTERA PHYSALUS)* IN THE SLOVENIAN MUSEUM OF NATURAL HISTORY

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SUMMARY

On March 10th, 2003, a dead female fin whale was found in the Bay of Piran. The 13.2 m long body was already in

the phase of decomposition. As the Slovenian Museum of Natural History took an interest in the carcass, the Ministry of the Environment, Spatial Planning and Energy and the Ministry of Transport and Communications issued two decrees, allowing the carcass to be sunk at a depth of 20 metres near the outflow of the Piran sewage system. The work was carried out by Ugo Fonda and his team, which wrapped the carcass in a meshed sack, transported it to the place of planned sinking, weighted it with concrete blocks and sunk it to the sea floor. Due to various administrative complications and eventual bad weather, the carcass was sunk as late as on March 17th. According to the assessment of the diving team, which surveyed the body each month, the decomposition had no detrimental effects on the immediate environment. Considering that the decomposition, which was mostly bacterial, progressed at a fast rate, the diving team and the employees of the Museum of Natural History lifted the whale's lower mandibles on July 7th, 2003. As much decomposed tissue was still present in the part of articular process, the Museum decided to postpone the lifting of the remaining carcass till 2004.

On March 13th, 2003, the Museum of Natural History received a letter from the Piran Council, in compliance with which the body of the found whale was to be handed to them. As this initiative was given much attention by the mass media, an impression was created in public that the whale's ownership was not known. The Ministry of the Environment and Physical Planning therefore issued a legal interpretation of the Decree on the protection of endangered animal species, according to which the whale's body fell completely within the competence of the Slovenian Museum of Natural History.

Key words: fin whale, *Balaenoptera physalus*, decomposition, Slovenian Museum of Natural History, legal aspects, Slovenia

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THE STRUCTURE AND SEASONAL VARIATIONS OF *BANGIA ATROPURPUREA* (ROTH) C. AGARDH (BANGIALES, RHODOPHYCEAE) COMMUNITY FROM THE SLOVENIAN COAST (NORTHERN ADRIATIC)

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ABSTRACT

The results of a study on Bangia atropurpurea *community, carried out in 2003 on hard substrata of the upper midlittoral zone at two stations on the Slovenian coast (northern Adriatic Sea), are presented. The investigation was based on monthly sampling that permitted a better characterization of the floristic composition, seasonal variations, community structure and reproductive phenology of* B. atropurpurea *at both stations.*

Key words: *Bangia atropurpurea* community, marine vegetation, northern Adriatic Sea

STRUTTURA E PERIODISMO DEL POPOLAMENTO A BANGIA ATROPURPUREA *(BANGIALES, RHODOPHYCEAE) DELLA COSTA DELLA SLOVENIA (ALTO ADRIATICO)*

SINTESI

Vengono presentati i risultati di uno studio su un popolamento a Bangia atropurpurea, *svolto nel 2003 e presente su substrato duro del mediolitorale superiore in due stazioni della costa della Slovenia (alto Adriatico). Lo studio, basato su rilievi mensili, ha permesso di meglio caratterizzare tale popolamento riguardo la composizione floristica, la variazione stagionale, la struttura e la fenologia riproduttiva della* B. atropurpurea *in entrambi le stazioni.*

Parole chiave: popolamento a *Bangia atropurpurea*, vegetazione marina, alto Adriatico

INTRODUCTION

The red algae belonging to the genus *Bangia* are cosmopolitan entities widely distributed from subtropical to colder regions of both hemispheres. They have a great capacity to tolerate a wide range of salinity, so are commonly found in both freshwater and marine habitats (Sheath & Cole, 1980, 1984).

Bangia atropurpurea (Roth) C. Agardh is the only species of the genus *Bangia* known from freshwater and marine habitats of the Mediterranean region, although numerous species of the same genus have been described from the Mediterranean areas, but under different names (Trevisan De Saint Leon, 1841; Ardissone, 1883; De Toni, 1897, 1904; Preda, 1908). Marine populations of *B. atropurpurea* usually occur in a wide zone above the water line (upper midlittoral) in moderately exposed habitats (Gargiulo *et al.*, 1991).

The thallus of the algae *B. atropurpurea* is formed by filaments usually 5–10 cm long, aggregated into patches. The filaments are attached at base adhering closely to rocks with rhizoids. Filaments are purple-violet in colour, but often more reddish in summer; initially, they are uniseriate, but eventually become multiseriate through successive divisions of the cells. The life-cycle of the Mediterranean *B. atropurpurea* species consists of two distinct heteromorphic phases involving an alternation between macroscopic, gametophytic phase, and microscopic sporophytic, *"conchocelis"* phase. The thalli of this species consist of different types of filaments: vegetative, sporophytic, gametophytic male and female. Vegetative filaments are uniseriate and multiseriate and produce monospores. Gametophytic filaments form male and female reproductive structures on separate thalli. Male filaments produce spermatia, while female filaments produce carpogonia. After fertilization, the developed zygotosporangia produce zygotospores. Spores germinate in uniseriate-branched sporophytic filaments, which represents the conchocelis phase. The conchocelis filaments release conchospores that germinate forming new gametophytic filaments (Gargiulo *et al.*, 1996).

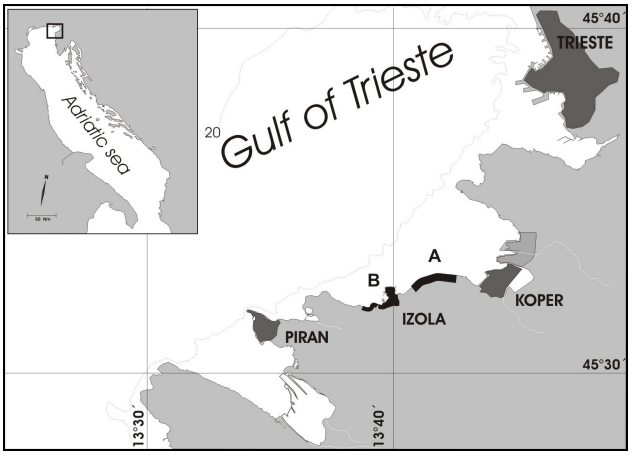

Fig. 1: Study area with sampling stations A and B.
Sl. 1: Raziskovalno območje z vzorčevalnima postajama A in B.

Temperature and photoperiod are the most important ecological factors acting in the regulation of the sporophytic and gametophytic phase alternation of *Bangia* populations in nature. Gametophytic filaments occur in the upper part of the midlittoral zone from winter to springtime. It is notable that the macroscopic phase begins to disappear in nature at temperatures higher than 25 °C (Gargiulo *et al.*, 1996, 1998).

The Mediterranean marine *B. atropurpurea* communities have been described by many authors, such as Lorenz (1863) who reported them from the Adriatic Sea as *"Bangieta";* Funk (1927) included them in the association with *Bangia-Enteromorpha-Corallina* from Naples (Italy); Feldmann (1937) described the "Association à *Bangia-Ulothrix"* from France; Boudouresque (1971) included this community in the facies *Chthamaletum stellati* (Feldmann) Boudouresque 1971. Recently, Ballesteros (1992) described the presence of a "Comunitat de *Bangia*" from Spain. In their phytosociological revision of both supralittoral and midlittoral marine algal communities from the Mediterranean Sea, Giaccone *et al.* (1993) described the *Bangietum atropurpureae* Giaccone 1993 association with *B. atropurpurea* and *Ulothrix flacca* (Dyllwin) Thuret, as characteristic species.

Along the Slovenian coast, *B. atropurpurea* is widely distributed on rocks or, during high tides, especially in habitats moderately exposed to wave action subjected to frequent exposure to air and desiccation. The *B. atropurpurea* community is visually recognized as closely adherent, often shiny purplish red to brownish mats of filamentous growth. In late winter and early spring, *B. atropurpurea* may the community's predominant species. The presence of *B. atropurpurea* along the Slovenian coast has been reported by Matjašič & Štirn (1975), Vukovič (1980, 1981, 1982, 1984), Munda (1988, 1991, 1993), Turk & Vukovič (1994), Vrišer & Vukovič (1996) and Battelli (2000, 2002). The presence of *B. atropurpurea* in Slovenian coastal waters was documented in the work "Cenno sulle alghe di Capodistria", in which its author Accurti (1858) described the marine algal vegetation from Koper Bay (Koprski zaliv). Historically important algal collections with many samples of this species, collected along Slovenian coastal waters, are found in museums, scientific and educational institutions, such as: Museo Civico di Storia Naturale in Trieste, Italy (Accurti and Zaratin collections); "Gian Rinaldo Carli" Grammar School in Koper, Slovenia (Zaratin collection); Center for Marine Research Rovinj, Croatia (Zaratin collection); minorite monasteries in St. Francis's monastery of Cres, Croatia (Titius collection), monastery of the Holy Spirit in Zagreb, Croatia, and Biblioteca Antoniana

in Padova, Italy (both from Titius collection) (Alberti & Battelli, 2001).

The purpose of this study was to investigate the floristic composition, structure and seasonal variations of *B. atropurpurea* community on hard substrata of the midlittoral zone from two stations on the Slovenian coast, *i.e.* on the Koper – Izola shore and along St. Simon Bay (Simonov zaliv). The research was carried out monthly during the year, which permitted a better characterization of the reproductive phenology of *B. atropurpurea* algae.

MATERIALS AND METHODS

The study was carried out on the hard substrata in the upper midlittoral zone at two stations on the Slovenian coast (northern Adriatic Sea) (Fig. 1). The first sampling station (station A) is situated in Koper Bay between the towns of Koper and Izola. The shore consists of limestone breakwater rocks with an extent of approximately 5 km. It is exposed to wave action and open to winds from the northwest (NW) and northeast (NE). The second sampling station (station B) is situated in St. Simon Bay near Izola; it is a stretch of rocky shore with a horizontal scope of about 250 m. The area is exposed to wave action and open to winds blowing from southwest (SW) to northeast (NE). The substratum consists of limestone with alveolines and nummulites (Pavlovec, 1985). Both stations are influenced mainly by the north-north-easterly wind (known as *"burja"* or *"bora").*

During this investigation, the tidal range was about 150 cm and the sea surface temperature ranged from 8.5 °C in January to 26.2 °C in August (Tab. 1).

Tab. 1: Sea surface temperature (°C) during the investigation period (January-December 2003).
Tab. 1: Temperatura površine vode (°C) v času raziskave od januarja do decembra 2003.

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Temp.	8.5	9.2	11.2	12.7	19.2	24.8	24.9	26.2	23.5	20.2	17.4	14.2

In total, 36 samples were collected from January to December 2003. At each station, three quantitative samples were collected monthly and randomly from the hard substrata by direct method from the upper midlittoral zone. All algae were removed from 100 cm^2 (10 cm x 10 cm) squares chosen in the areas where the community was detectable by the naked eye. Care was taken to collect samples at least 1 m away from each other. The collected material was stored in 4% seawater-formalin solution and examined in the laboratory using a microscope to determine algal species and to estimate the cover of each species. Abundance of species was expressed as percentage cover. A 10 x 10 cm square was divided into 100 sub-squares and the sum of the sub-squares covered by single species was treated as the percentage cover for that particular species. Voucher specimens were made and kept in personal herbarium.

Following Boudouresque (1971) and in order to better define the community's structure, the species number (N), percentage cover (Ri) and Shannon-Weaver diversity index (H') were calculated for each month and each season for each sample. Moreover, the quantitative dominance (DR % = Ri/Rt x 100) was calculated for *B. atropurpurea*. To evaluate the similarity on the basis of floristic composition between the two stations, the Soerensen's index (SQ) was calculated as well.

The reproductive phenology of *B. atropurpurea* was also studied throughout the year, noting the occurrence in different months of non-reproductive filaments (uniseriate and pluriseriate), male gametophytic filaments with spermatia, female gametophytic filaments with carpogonia, and zygotospores and filaments with monospores.

Algal nomenclature of Drouet (1981), Ribera *et al.* (1992), Gallardo *et al.* (1993) and Silva *et al.* (1996) was used.

To delineate phytogeographic regions of benthic algae, the following scheme was used: Atlantic **A** (including **Ab** – Atlantic-boreal, **Abt** – Atlantic boreo-tropical, **AP** – Atlanto-Pacific, **APct** – Atlanto-Pacific cold temperate, **At** – Atlantic tropical, **IA** – Indo-Atlantic, **IAt** – Indo-Atlantic tropical, **IAct** – Indo-Atlantic cold temperate taxa); Cosmopolite **C** (also including **SC** – Subcosmopolitan); **CB** – Circumboreal; **IP** – Indo-Pacific; **M** – Mediterranean and **P** – Pantropical (Furnari *et al.*, 1999).

RESULTS AND DISCUSSION

Floristic composition

The results revealed that at the two stations the floristic composition of the *B. atropurpurea* communities was basically the same. It consisted of 14 species: Cyanobacteria dominated with 7 species, Chlorophyceae were represented by 4 species, Rhodophyceae were present with 2 species, while the Fucophyceae were represented by the smallest number of species, *i.e.* one species only at station B (Tab. 2).

Tab. 2: Floral numerical and percentage composition at sampling stations.
Tab. 2: Število in odstotek taksonov na vzorčevalnih postajah.

	Station A	**Station B**
Cyanobacteria	7 (53.8%)	7 (50.0%)
Rhodophyceae	2 (15.4%)	2 (14.3%)
Fucophyceae	–	1 (7.1%)
Chlorophyceae	4 (30.8%)	4 (28.6%)
Total	**13**	**14**

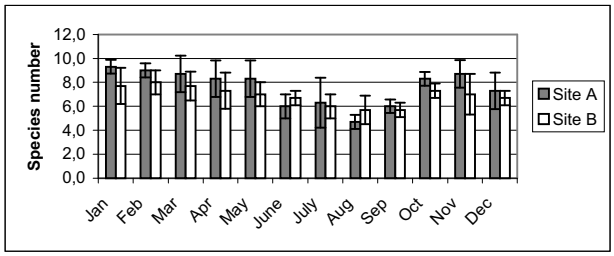

Fig. 2: Monthly variation of means (± SD, n=12) of species number at sampling stations.
Sl. 2: Mesečne variacije srednje vrednosti števila vrst (± SD, n=12) na vzorčevalnih postajah.

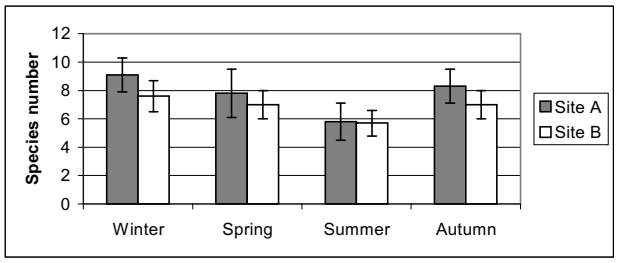

Fig. 3: Seasonal variation of means (± SD, n=9) of species number at sampling stations.
Sl. 3: Sezonske variacije srednje vrednosti števila vrst (± SD, n=9) na vzorčevalnih postajah.

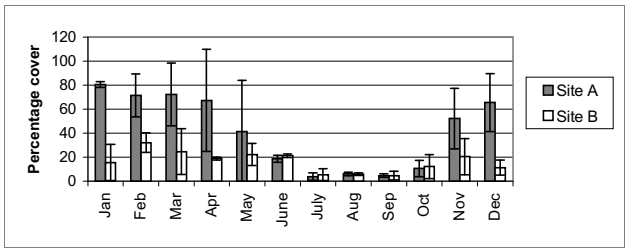

Fig. 4: Monthly variation of means (± SD, n=12) of percent cover of algae at sampling stations.
Sl. 4: Mesečne variacije srednje vrednosti pokrovnosti alg (± SD, n=12) na vzorčevalnih postajah.

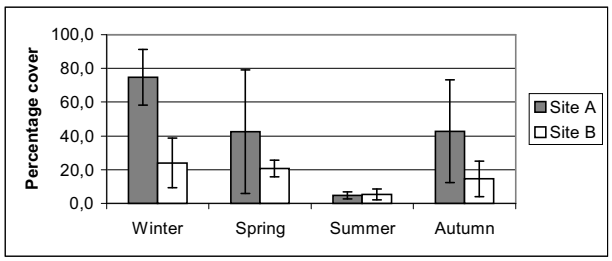

Fig. 5: Seasonal variation of means (± SD, n=9) of percent cover of algae at sampling stations.
Sl. 5: Sezonske variacije srednje vrednosti pokrovnosti alg (± SD, n=9) na vzorčevalnih postajah.

Seasonal variations

At station A, the mean species number decreased slightly from January to August, then increased from August to November, and eventually decreased again in December. At station B, the situation did not follow the same trend. It increased slightly from January and then decreased by September; it increased again in October and then decreased by December (Fig. 2). Seasonal variations of the mean species number for both stations showed the same trend: it decreased from winter to summer and then increased by autumn. Although the mean species number at station A was slightly higher than at station B, the analysis showed basically the same values for both stations in the summer months, 5.7 at station A and 5.8 at station B (Fig. 3).

Community structure

The mean percentage cover at station A was markedly higher (41.2%) then at station B (16.2%) (Tabs. 3 and 4). Temporal fluctuation of the mean percentage cover at station A decreased markedly from January to July, then increased slightly by October, and eventually increased markedly by December. The algal cover at station B did not follow the same trend. It increased from January to February and then decreased slightly by September. After that, a slight increase was observed till November, while in December the cover decreased markedly (Fig. 4). Seasonal variation of the mean percentage cover at station A showed the highest values during the spring and autumn, *i.e.* 74.8% and 42.8% respectively. The algal cover decreased markedly from winter to spring and then increased from summer to autumn. The lowest values were calculated in the summer, only 4.8%. At station B, the situation followed the same trend, although the values were basically lower than at station A. It should be noted that the cover values at both stations in the summertime were very similar, *i.e.* 4.8% at station A and 5.3% at station B (Fig. 5).

The mean Shannon-Weaver index value at station A was slightly lower (0.7) than at station B (1.0) (Tabs. 3 and 4). The analysis of temporal fluctuation of diversity mean values indicated some differences between the two florae. In general, the values at station A were slightly lower than at station B during all months, except in July when the value at station A was markedly higher (1.2) than at station B (0.8) (Fig. 6). The mean diversity seasonal fluctuation at station A showed the highest value in the summer (1.0) and the same values during the winter

Tab. 3: *B. atropurpurea* ***community of the Koper-Izola coast. The reproductive phenology is reported only for*** *B. atropurpurea* ***as: m = male gametophyte, f = female gametophyte, j = juvenile stage. (For the names of species see Annex – check list.) *Cover abundance values (see Table 4)***

Tab. 3: Združba z vrsto *B. atropurpurea* ***vzdolž obale Koper – Izola. Reproduktivna fenologija je prikazana le za vrsto*** *B. atropurpurea* ***in sicer: m = moški gametofit, f = ženski gametofit, j = začetni štadij razvoja. (Za imena vrst glej Annex – check list.) *Vrednosti pokrovnosti (glej Tabelo 4)***

Sub-area	**8**			**4**			**5**			**6**			**12**			**2**		
Month	January			February			March			April			May			June		
Sample	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Season	**Winter**									**Spring**								
Surface/cm²	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
Depth/cm	40	35	40	45	35	40	35	30	30	35	45	45	30	40	30	40	45	30
Exposition	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
Characteristic species																		
B. atropurpurea	4mf	4mf	4mf	4mf	3mf	3mf	4f	5f	3f	5f	5f	2f	5f	2f	2f	2f	2f	2f
U. flacca	2	2	2	1	3	+	1	1	+	1	1	+	-	1	+	-	1	-
Others species																		
C. crustacea	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
M. lyngbyaceus	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
E. deusta	+	+	1	+	+	1	+	+	1	+	+	+	+	+	+	+	+	1
B. minima	1	+	+	+	2	2	2	1	1	+	1	1	1	+	+	-	1	1
E. conferta	+	+	+	+	+	+	+	+	+	+	-	+	-	+	+	-	+	-
P. leucosticta	+	+	+	1	+	-	+	+	-	+	+	-	+	+	-	-	-	-
U. compressa	1	+	+	+	-	+	-	+	-	+	-	-	+	+	+	-	-	-
A. dimidiata	+	-	-	-	+	-	-	+	-	+	-	+	-	+	-	+	-	+
S. calcicola	-	-	-	-	+	-	-	-	-	+	-	-	-	-	-	+	-	-
U. clathrata	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
B. quojii	-	-	-	+	-	-	-	+	-	-	-	-	-	-	-	-	-	-
% Cover	83.1	78.2	80.6	68.2	90.6	55.5	80.5	93.3	42.9	90.8	92.9	18.1	90.5	18.3	15.7	15.4	20.4	20.3
Diversity (H')	0.8	0.6	0.7	0.4	1.1	0.8	0.7	0.3	0.5	0.2	0.3	0.6	0.2	0.7	0.3	0.2	0.8	0.8
Species number	10	9	9	10	10	8	8	11	7	11	7	8	7	10	8	6	7	6
Evenness (J)	0.3	0.3	0.3	0.2	0.5	0.4	0.3	0.1	0.3	0.1	0.2	0.3	0.1	0.3	0.1	0.1	0.4	0.5

Sub-area	**7**			**10**			**1**			**9**			**3**			**4**					
Month	July			August			September			October			November			December					
Sample	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36			
Season	**Summer**									**Autumn**											
Surface/cm²	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100			
Depth/cm	45	35	45	40	45	35	40	30	30	30	45	40	35	40	35	40	30	40			
Exposition	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N			
Characteristic species																			Ri	P	Clas-ses
B. atropurpurea	1f	+f	-	-	-	-	-	-	-	1j	+j	+j	2f	4f	3f	3mf	5mf	4mf	32.6	29	IV
U. flacca	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+		16	III
Other species																					
C. crustacea	+	+	+	+	1	1	+	1	1	+	1	1	+	+	+	+	+	+		36	V
M. lyngbyaceus	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+		36	V
E. deusta	+	+	+	1	+	1	1	+	+	1	+	1	1	+	1	+	+	1		36	V
B. minima	+	1	-	1	-	-	+	+	+	+	2	1	2	2	1	+	+	-		31	V
E. conferta	1	1	+	1	1	+	1	1	-	+	+	+	+	+	+	-	+	+		30	V
P. leucosticta	-	-	-	-	-	-	-	-	-	-	+	+	+	+	+	1	+	1		19	III
U. compressa	+	+	-	-	-	-	+	-	-	-	+	-	-	1	+	-	+	-		17	III
A. dimidiata	-	+	-	-	+	-	-	+	+	+	-	+	-	+	-	-	+	-		16	III
S. calcicola	-	-	-	-	+	-	-	-	-	-	+	-	-	-	-	-	+	-		6	I
U. clathrata	-	-	-	-	-	-	-	-	-	+	+	-	+	+	-	-	-	-		4	I
B. quojii	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-		3	I
% Cover	5.5	5.6	0.4	7.7	5.3	5.2	5.4	5.4	3.0	5.6	18.2	8.0	33.0	80.7	43.0	40.4	88.3	67.9	41.2		
Diversity (H')	1.1	1.2	1.4	1.2	0.9	0.9	1.0	1.0	0.6	1.2	0.6	1.4	1.0	0.7	0.5	0.3	0.1	0.4	0.7		
Species number	7	8	4	5	6	4	6	6	6	8	10	8	8	10	8	6	10	7	7.6		
Evenness (J)	0.6	0.6	1.0	0.7	0.6	0.6	0.6	0.6	0.3	0.6	0.3	0.7	0.5	0.3	0.2	0.2	0.05	0.2	0.4		

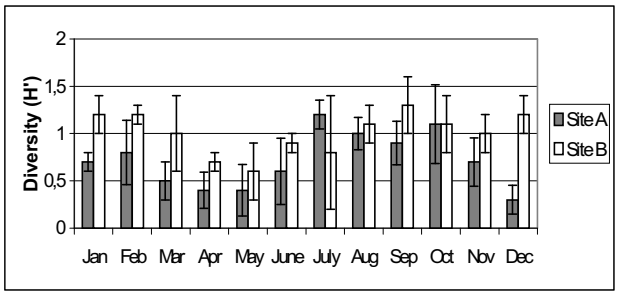

Fig. 6: Monthly fluctuations of means (± SD, n=12) of the Shannon-Weaver diversity index (H') of florae at sampling stations.
Sl. 6: Mesečne variacije srednje vrednosti (± SD, n=12) Shannon-Weaverjevega diverzitetnega indeksa (H') na vzorčevalnih postajah.

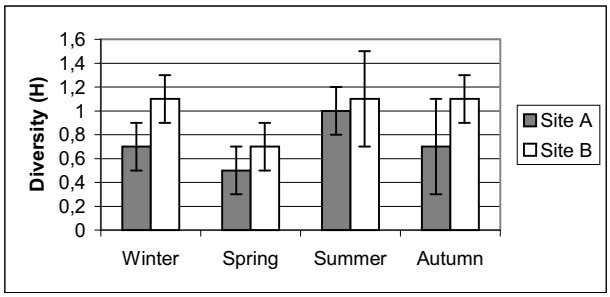

Fig. 7: Seasonal fluctuations of means (± SD, n=9) of the Shannon-Weaver diversity index (H') of florae at sampling stations.
Sl. 7: Sezonske variacije srednje vrednosti (± SD, n=9) Shannon-Weaverjevega diverzitetnega indeksa (H') na vzorčevalnih postajah.

and autumn months. Conversely at station B the value was the same (1.1) throughout the seasons, except in spring when it reached the minimum value (0.7) (Fig 7).

The mean evenness value at station A (0.4) was slightly lower than at station B (0.5) (Tabs. 3 and 4). Temporal variations were basically constant at both stations during all months, although the values at station B were slightly lower than at station A. The analysis showed that only in July the value at station A was slightly higher than at station B (Fig. 8). Conversely, the seasonal mean values of evenness decreased slightly from winter to spring at both stations and then increased markedly by summer reaching the same value (0.6). From summer to autumn, the values remained the same at station B, while at station A they decreased markedly by autumn (Fig. 9). The low evenness values throughout the study period indicate a dominance of a small number of species at both stations particularly in the winter, spring and autumn months due to the presence of gametophytic phase of *B. atropurpurea.*

The results of the study revealed that at both stations the species *B. atropurpurea* was well developed in the upper midlittoral zone of the examined area, forming a belt of dense turf, with a very patchy and irregular distribution. The mean total cover value of *B. atropurpurea* at station A (32.6%) was markedly higher than at station B (8.3%) (Tabs. 3 and 4). The comparison of the percentage cover of this species at the two stations throughout the year showed basically the same trend, although the values at station A were markedly higher than at station B (Fig 10). The percent cover means of *B. atropurpurea* showed great seasonal variations at both stations; the values decreased markedly from winter to spring, reaching the minimum in the summer months and then increased by the autumn (Fig. 11).

The seasonal trend of *B. atropurpurea* quantitative dominance was evident and basically the same at both sampling stations, although the values at station A were markedly higher than at station B (Fig. 12). The values reached the maximum in winter and spring, while the minimum was reached in the summer months due to the seasonal development of this species. As mentioned above, the macroscopic (gametophytic) phase begins to disappear during the summer, when the temperature of the sea is higher than 24 °C (the microscopic (sporophytic) phase has different ecology).

Reproductive phenology of *Bangia atropurpurea*

Different seasonal patterns were manifested, when the reproductive phenology of *B. atropurpurea* was taken into consideration due to the seasonality of the gametophytic phase. Gametophytic filaments appeared in the autumn months, reaching the cover maximum development and values from January to May, and then disappeared in the summer months. For this species, the non-reproductive uniseriate filaments and three types of multiseriate filaments, *i.e.* non-reproductive, female and male, were recorded during this study at both stations. We found that monospores were produced in both, uniseriate and multiseriate non–reproductive filaments, and that gametophytic thalli formed male and female reproductive structures on separate thalli.

The presence in the field of filaments with zygotospores, monospores and gametes is shown in Table 3. Although the values of species number, percentage cover and quantitative dominance of *B. atropurpurea* in different months and seasons varied slightly at both stations, it can be concluded that the examined communities were quite similar at both stations. This is supported by the fact that all the species, except *Fucus virsoides,* present at station B, were common at both stations as well as expressed by the high SQ value (0.96). The low diversity index value of both florae (0.7 at station A and 1.0 at station B) indicated a low community complexity at both stations. The seasonal fluctuation of species number and percentage

Tab. 4: *B. atropurpurea* ***community of St. Simon Bay (Simonov zaliv). The reproductive phenology is reported only for*** *B. atropurpurea* ***as: m=male gametophyte, f=female gametophyte, j=juvenile stage. (For the names of species see Annex – check list.)***

Tab. 4: Združba z vrsto *B. atropurpurea* ***pri Simonovem zalivu. Reproduktivna fenologija je prikazana le za vrsto*** *B. atropurpurea****, in sicer: m = moški gametofit, f = ženski gametofit, j = začetni štadij razvoja. (Za imena vrst glej Annex – check list.)***

Sub-area	**8**			**4**			**5**			**6**			**12**			**2**		
Month	January			February			March			April			May			June		
Sample	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Season	**Winter**									**Spring**								
Surface/cm²	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
Depth/cm	40	35	40	45	35	40	35	30	30	35	45	45	30	40	30	40	45	30
Exposition	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
Characteristic species																		
B. atropurpurea	1mf	2mf	1mf	2mf	2mf	2mf	1f	2f	3f	2f	2f	2f	2f	2f	2f	2f	2f	2f
U. flacca	+	-	+	1	-	+	1	-	+	+	-	+	-	-	+	+	-	-
Other species																		
C. crustacea	+	+	+	+	1	1	+	+	1	+	+	+	+	+	+	1	1	+
M. lyngbyaceus	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
E. deusta	1	1	1	1	1	1	1	1	1	1	1	+	+	1	+	1	1	1
B. minima	1	2	+	1	1	2	+	1	1	+	1	1	+	2	+	-	1	1
S. calcicola	+	-	-	-	+	+	+	-	+	-	+	-	-	-	+	-	+	-
A. dimidiata	+	-	-	-	+	-	-	+	-	+	-	+	-	+	-	+	-	+
E. conferta	-	+	-	-	-	+	-	-	+	-	-	-	-	-	-	-	+	-
P. leucosticta	+	-	-	2	-	-	+	-	-	+	-	-	1	-	-	+	-	-
U. compressa	-	-	+	-	-	+	-	-	-	+	-	-	+	-	+	-	-	-
B. quojii	-	+	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-
U clathrata	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
F. virsoides	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-
% Cover	8.1	32.9	5.5	37.8	22.8	35.5	8.0	20.4	45.4	18.2	20.3	18.0	18.0	32.8	15.7	20.4	22.8	20.3
Diversity (H)	1.4	1.0	1.1	1.3	1.1	1.2	1.4	0.8	0.7	0.6	0.8	0.6	0.6	1.0	0.3	0.8	1.1	0.8
Species number	9	7	7	8	7	9	8	7	8	9	6	7	7	6	8	7	7	6
Evenness (J)	0.6	0.5	0.6	0.6	0.6	0.5	0.7	0.4	0.3	0.3	0.5	0.3	0.3	0.5	0.1	0.4	0.6	0.5

Sub-area	**7**			**10**			**1**			**9**			**3**			**4**					
Month	July			August			September			October			November			December					
Sample	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36			
Season	**Summer**									**Autumn**											
Surface/cm²	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100			
Depth/cm	45	35	45	40	45	35	40	30	30	30	45	40	35	40	35	40	30	40			
Exposition	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N			
Characteristic species																			Ri	P	Classes
B. atropurpurea	1f	+f	+f	-	-	-	-	-	-	-	+j	+j	1f	1f	2f	1mf	2mf	1mf	8.3	29	V
U. flacca	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	1	-	+		13	II
Other species																					
C. crustacea	1	1	+	1	+	1	1	+	1	1	1	1	1	+	1	+	1	1		36	V
M. lyngbyaceus	+	+	+	+	+	1	+	+	1	+	+	+	+	+	+	+	+	+		36	V
E. deusta	+	1	+	+	1	1	1	+	+	+	1	1	+	1	2	+	+	1		36	V
B. minima	-	1	-	1	-	-	1	+	+	+	2	1	+	2	1	+	+	-		30	V
S. calcicola	+	-	+	-	+	+	+	-	-	+	+	-	-	-	+	+	-	+		18	III
A. dimidiata	-	+	-	-	+	-	-	+	+	-	-	+	-	+	-	-	+	-		15	III
E. conferta	-	1	-	-	1	+	-	-	-	-	1	1	-	-	+	-	-	-		10	II
P. leucosticta	-	-	-	-	-	-	-	-	-	+	-	-	+	-	-	-	-	1		9	II
U. compressa	+	-	-	-	-	-	+	-	-	-	-	-	-	-	+	-	-	-		8	II
B. quojii	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-		3	I
U clathrata	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-		1	I
F. virsoides	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-		1	I
% Cover	5.4	10.3	0.5	5.2	5.4	7.2	7.8	0.6	5.3	3.1	22.8	10.3	5.4	20.3	35.5	5.5	17.9	10.3	16.2		
Diversity (H)	1.0	1.3	0.2	0.9	1.1	1.3	1.3	1.6	0.9	0.8	1.1	1.5	1.0	0.8	1.2	1.1	1.0	1.5	1.0		
Species number	6	7	5	5	7	5	6	6	5	8	7	7	6	6	9	7	6	7	6.9		
Evenness (J)	0.6	0.7	0.1	0.6	0.6	0.8	0.7	0.9	0.6	0.4	0.6	0.8	0.6	0.5	0.5	0.6	0.6	0.8	0.5		

Class	**% Cover**	**Average values**
+	<1	0.1
1	1.1 – 5.0	2.5
2	5.1 – 25.0	15.0
3	25.1 – 50.0	37.5
4	50.1 – 75.0	62.5
5	75.1 – 100	87.5

****Cover abundance values / *Vrednosti pokrovnosti***

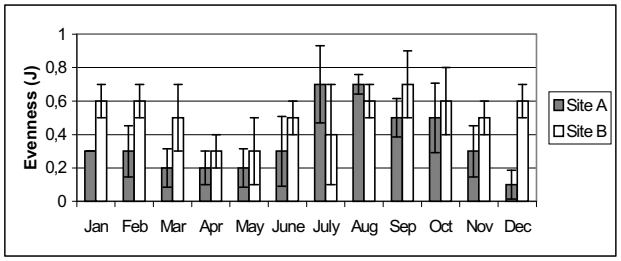

Fig. 8: Monthly fluctuations of means (± SD, n=12) of evenness (J) of florae at sampling stations.
Sl. 8: Mesečne variacije srednjih vrednosti (± SD, n=12) indeksa enakomernosti porazdelitve (J) flore na vzorčevalnih postajah.

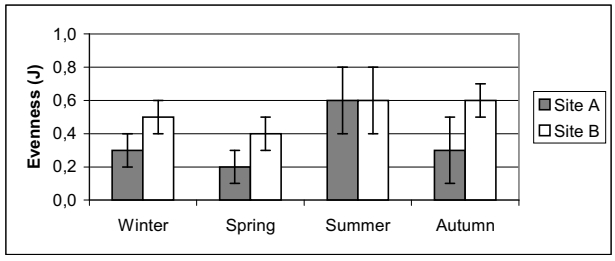

Fig. 9: Seasonal fluctuations of means (± SD, n=9) of evenness (J) of florae at sampling stations.
Sl. 9: Sezonske variacije srednjih vrednosti (± SD, n=9) indeksa enakomernosti porazdelitve (J) flore na vzorčevalnih postajah.

cover at both stations was basically the same, although the values at station A were higher. The mean evenness values were low at both stations and temporal variations of these values followed basically the same trend, although a slight increase of the values was observed during the summer months. The low evenness values indicate a dominance of a small number of species at both stations especially in the winter, spring and autumn months due to development of some seasonal algae, such as *B. atropurpurea* and *Porphyra leucosticta*. On the basis of this study, the *B. atropurpurea* community of both stations may be considered from the syntaxonomic point of view as the association *Bangietum atropurpureae* Giaccone 1993. The author put as characteristics species *B. atropurpurea* and *Ulothrix flacca* in the phytocenological table of sample made during May with the mean of species number value of 9 (Giaccone *et al.*, 1993).

In both florae, cosmopolitan (10) and subcosmopolitan (3) elements dominate, whereas the Mediterranean elements are represented by a single species *(F. virsoides,* only at station B) (Annex – check list).

Tab. 5: Presence in the field of filaments with different spore types and gametes of** B. atropurpurea **during the period January-December 2003.
Tab. 5: Reproduktivna fenologija vrste** B. atropurpurea **v času vzorčevanja od januarja do decembra 2003.

Month	Spermatangia	Carpogonia	Zygotospores	Monospores
January	+	+	+	+
February	+	+	+	+
March	-	+	+	+
April	-	+	+	+
May	-	+	+	+
June	-	+	-	+
July	-	+	-	+
August	-	-	-	-
September	-	-	-	-
October	-	-	-	-
November	-	+?	-	-
December	+	+?	-	+

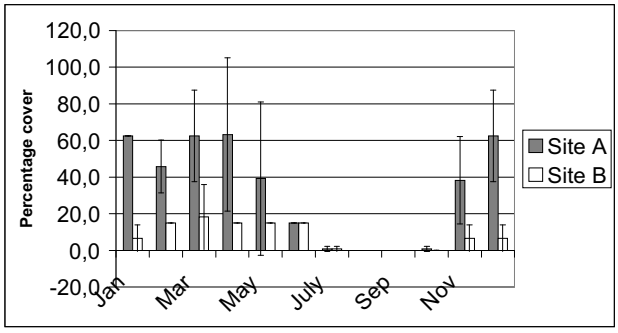

Fig. 10: Monthly variation of means (± SD, n=12) of percentage cover of** B. atropurpurea **at sampling stations.
Sl. 10: Mesečne variacije srednje vrednosti (± SD, n=12) pokrovnosti vrste** B. atropurpurea **na vzorčevalnih postajah.

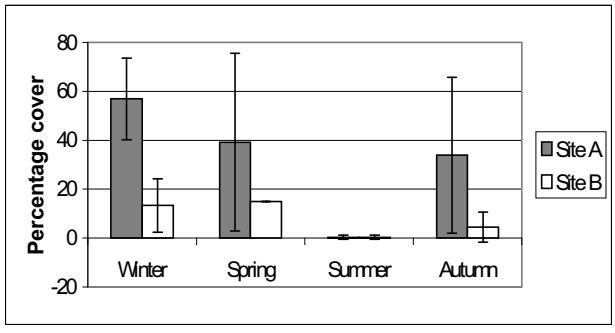

Fig. 11: Seasonal variation of means (± SD, n=9) of percentage cover of** B. atropurpurea **at sampling stations.
Sl. 11: Sezonske variacije srednje vrednosti (± SD, n=9) pokrovnosti vrste** B. atropurpurea **na vzorčevalnih postajah.

Annex – check list

Cyanobacteria
Anacystis dimidiata (Kützing) Drouet & Daily **C**
Brachytrichia quojii (C. Agardh) Bornet & Flahault **C**
Calothrix crustacea Thuret **C**
Entophysalis conferta (Kützing) Drouet & Daily **C**
Entophysalis deusta (Meneghini) Drouet & Daily **C**
Microcoleus lyngbyaceus (Kützing) Drouet **C**
Schizothrix calcicola (C. Agardh) Gomont **C**

Rhodophyceae
Bangia atropurpurea (Roth) C. Agardh **C**
Porphyra leucosticta Thuret in Le Jolis **SC**

Fucophyceae
Fucus virsoides C.Agardh **M**

Chlorophyceae
Blidingia minima (Nägeli ex Kützing) Kylin **SC**
Ulva clathrata (Roth) C. Agardh **C**
Ulva compressa Linnaeus **C**
Ulothrix flacca (Dillwyn) Thuret **SC**

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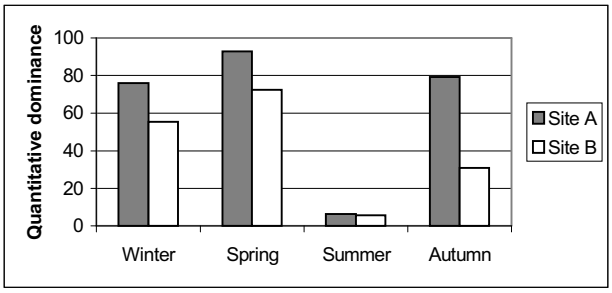

Fig. 12: Seasonal variation of quantitative dominance of** B. atropurpurea **at examined sites.
Sl. 12: Sezonske variacije količinske dominance vrste** B. atropurpurea **na vzorčevalnih postajah.

SESTAVA IN SEZONSKA SPREMENLJIVOST ZDRUŽBE Z VRSTO *BANGIA ATROPURPUREA* (ROTH) C. AGARDH (BANGIALES, RHODOPHYCEAE) SLOVENSKEGA MORSKEGA OBREŽJA (SEVERNI JA DRAN)

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POVZETEK

Prispevek obravnava floristično in fitogeografsko sestavo ter sezonske variacije združbe z vrsto Bangia atropurpurea *na dveh postajah slovenskega morskega obrežja (severni Jadran). Namen raziskave je bil opredeliti združbo z vrsto* B. atropurpurea *s floističnega vidika in sezonske spremenljivosti.*

Raziskava je potekala na dveh stalnih vzorčevalnih postajah; ena na valolomnih kamnih vzdolž obalne ceste med Koprom in Izolo (postaja A), druga pa na naravni apnenčasti podlagi v Izoli pri Simonovem zalivu (postaja B). Določenih je bilo 14 vrst, in sicer 7 cianobakterij (50,0%), 2 vrsti rdečih alg (14,3%), 1 rjava (7,1%) in 4 vrste zelenih alg (28,6%).

Raziskava je pokazala, da je združba z vrsto B. atropurpurea *dobro razvita na obeh postajah v zgornjem delu mediolitorala v obliki gostega pasu z zelo nepravilno (mozaično) razporeditvijo. Povprečna vrednost pokrovnosti vrste* B. atropurpurea *na postaji A (32,6%) je bistveno večja od vrednosti na postaji B (8,3%). Fluktuacija vrednosti v letu je na obeh postajah zelo podobna: največje vrednosti so zabeležene v jesenskem, zimskem in spomladanskem času, kar se ujema z razvojnim krogom vrste* B. atropurpurea. *Nizke vrednosti diverzitetnega indexa (H') in visoke vrednosti indeksa podobnosti (SQ=0,96) kažejo na majhno kompleksnost te skupnosti. V obeh združbah prevladujejo kozmopolitski (10) in subkozmopolistski (3) elementi, medtem ko je bila od mediteranskih vrst zabeležena le ena, in sicer* Fucus virsoides *na postaji B.*

S fitocenološkega vidika združba z vrsto B. atropurpurea *predstavlja asociacijo* Bangietum atropurpureae *Giaccone 1993.*

Ključne besede: združba z vrsto *Bangia atropurpurea*, morska vegetacija, severni Jadran

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ALGAL FLORA OF FOUR DIFFERENT SPRINGS IN SLOVENIA

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ABSTRACT

Samples were taken seasonally at four different springs in Slovenia: the spring at Medvedje Brdo, the spring in Pohorje, the mineral Rimski vrelec spring, and the thermal Terme Čatež spring in the years 1999, 2000 and 2001. The paper presents the initial research carried out into the algae at the above four springs. The purpose of the investigation was to establish species composition and periphyton abundance. Some physical and chemical parameters were also measured. Altogether, 83 algal taxa were registered, with prevailing Bacillariophyceae (51), while 14 taxa belonged to Cyanophyceae, 11 to Chlorophyceae, four to Xanthophyceae and three to Zygnematophyceae. 11 taxa were new to Slovenia, most of them belonging to Bacillariophyceae.

Key words: algae, periphyton, springs, thermal springs

FLORA ALGALE PRESSO QUATTRO DIVERSE SORGENTI IN SLOVENIA

SINTESI

La ricerca prende in esame le alghe appartenenti al perifiton di quattro diverse sorgenti in Slovenia – quella di Medvedje Brdo, quella sul Pohorje, la sorgente minerale "Rimski vrelec" e la sorgente termale delle Terme Čatež – con lo scopo di registrare l'abbondanza e la composizione specifica delle comunità algali negli anni 1999, 2000 e 2001. Questa è la prima ricerca sulle alghe presenti nelle quattro sorgenti. Sono stati misurati anche alcuni fattori fisici e chimici. Nelle quattro sorgenti sono stati individuati complessivamente 83 diversi taxon appartenenti a cinque classi di alghe: Bacillariophyceae (51), Cyanophyceae (14), Chlorophyceae (11), Xanthophyceae (4) e Zygnematophyceae (3). 11 specie sono state individuate in Slovenia per la prima volta, la maggior parte apparteneva alle diatomee.

Parole chiave: alghe, perifiton, sorgenti, sorgenti termali

INTRODUCTION

Algae are a highly diverse group of organisms with important functions in aquatic habitats. They inhabit different biotopes: aerial biotopes, freshwater, salty water and brackish water. Some of them occur in extreme biotopes like snow, thermal springs, mineral waters, caves, peat bogs... In Slovenia, the number of extreme biotopes is very high due to its geographic diversity and relatively low degree of pollution. Algae in such biotopes have been only partly investigated (Kosi & Vrhovšek, 1996).

Thermal waters are waters with temperatures above 30 °C (Cvijan & Blaženčić, 1996). Typical algal flora of such waters is Cyanophyceae. Beside them, Bacillariophyceae, Chlorophyceae, Chrysophyceae, etc. occur in thermal waters (Cvijan & Blaženčić, 1996). Cyanophyceae are common in most thermal springs through the world with pH above 5 and temperature below 74 °C (Doemel & Brock, 1971). In thermal springs with pH below 5 and water temperature between 40 and 56 °C, Cyanophyceae do not occur any more; in such waters, only the species *Cyanidium caldarium* is present (Doemel & Brock, 1971). Most common genera in thermal springs of Slovenia are *Phormidium*, *Pleurocapsa* and *Calothrix* (Vrhovšek, 1985).

The objective of the investigation was to establish the species composition and periphyton abundance in the Medvedje Brdo spring, the spring in Pohorje, the mineral Rimski vrelec spring and the Terme Čatež thermal spring in the years 1999, 2000 and 2001. Some physical and chemical parameters were also measured. The paper presents the first algological research carried out at these four springs.

MATERIAL AND METHODS

Study sites

For the purpose of our investigation, we chose four different springs in Slovenia: the spring at Medvedje Brdo, the spring in Pohorje, the mineral Rimski vrelec spring and the thermal Terme Čatež spring. The sampling sites are presented in figure 1. The Medvedje Brdo spring is a karst spring on limestone ground. The water appears on the surface only 2-3 meters, then it sinks. The spring is shaded (co-ordinates after Gaus-Krüger: X=5091875, Y=5432750). The spring in Pohorje is located on acid-silicate ground in Lovrenška jezera Forest Reserve. The spring is not shaded (co-ordinates after Gaus-Krüger: X=5147725, Y=5524775). The mineral Rimski vrelec spring is situated behind Rimski vrelec Hotel at Kotlje near the town of Ravne na Koroškem. The spring water belonged to "Ca-Mg-Na-hydrogencarbonate acid waters" with very high values of iron (Rogelj *et al.*, 1972). The spring is shaded and regulated (fountain). The thermal Terme Čatež spring is situated between Toplice Hotels and Zimska termalna riviera. The spring is regulated (fountain) and not shaded. The thermal water is pumped out of the well into the fountain. The temperature of the thermal water is 64 °C (Nosan, 1973).

Sampling

The samples were collected seasonally during the years 1999, 2000 and 2001. Four periphyton samples were taken in the Medvedje Brdo spring (2.4.1999, 6.8.1999, 17.10.1999, 19.2.2000), the thermal Terme Čatež spring (28.3.2000, 16.9.2000, 20.11.2000, 15.1.2001) and the mineral Rimski vrelec spring (12.8.1999, 20.10.1999, 25.2.2000, 14.5.2000), and three in the Pohorje spring (7.8.1999, 16.10.1999, 3.6.2000). Periphyton samples were taken in the springs of Medvedje Brdo and Pohorje by scratching the surface of gravel and rocks in the water and overgrowth with mosses and in the mineral Rimski vrelec and Terme Čatež springs by scratching the bottom and the walls of the fountain. The fixation of the samples was done *in situ* with 4 % formalin concentration. For diatom determination, samples were pre-treated with saturated HNO_3 (APHA, 1985).

Taxa of the algae using light microscope (magnification 1000×) and following identification monographs were determined: Lazar (1960), Starmach (1966, 1968, 1972), Bourrelly (1968), Kramer & Lange-Bertalot (1986, 1988, 1991a, 1991b), Hindak *et al.* (1978), Hindak (1996), Cvijan & Blaženčić (1996). The abundance of

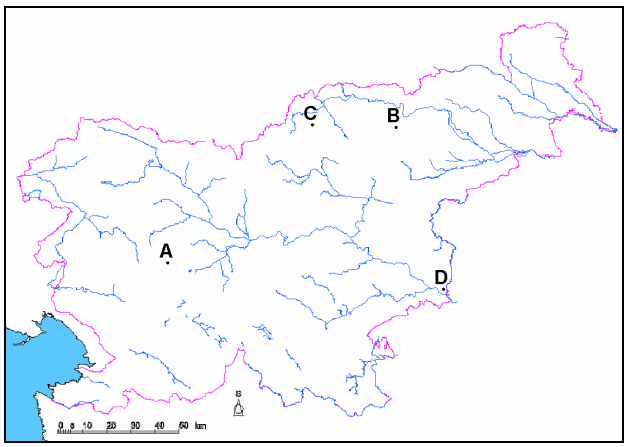

Fig. 1: Map of Slovenia with marked sampling sites. Legend: A – Medvedje Brdo spring, B – Pohorje spring, C – Rimski vrelec mineral spring, D – Terme Čatež thermal spring.
Sl. 1: Zemljevid Slovenije z označenimi vzorčnimi mesti. Legenda: A – izvir na Medvedjem Brdu, B – izvir na Pohorju, C – mineralni izvir Rimski vrelec, D – termalni izvir v Termah Čatež.

most common species was evaluated using the following scale (Pantle & Buck, 1995):

Abundance	species present in % of visible fields
1 – single	1-15
3 – customary	>15-60
5 – dominate	>60-100

In 1999 and 2000, various physical and chemical parameters were measured; these included temperature, conductivity, pH, dissolved oxygen and percentage saturation (APHA, 1985).

RESULTS AND DISCUSSION

Physical and chemical parameters

Range of some physical and chemical parameters at all four springs in the years 1999, 2000 and 2001 are presented in Table 1.

Water temperature of springs, which receive water from deeper layers, was more or less constant and oscillated around the average annual air temperature (Rejic, 1988). Such springs are also the Medvedje Brdo spring, the mineral Rimski vrelec spring, and the spring in Pohorje with minor temperature changes of water through the year. Temperatures of thermal waters exceed 30 °C (Cvijan & Blaženčić, 1996); such is also the thermal Terme Čatež spring, with its temperatures ranging, at the time of our measurements, from 46.4 °C to 55.5 °C.

Conductivity in freshwaters increases with increase of salinity, which is influenced by the ground and its geology, climate, temperature, dust, precipitation, evaporation, winds, distance from the sea, flora and fauna (Rejic, 1988). In the Pohorje spring, the conductivity at the time of our measurements was low (16.5–51.3 µS/cm), which can be explained by the acid-silicate ground. In the Rimski vrelec mineral spring, on the other hand, the conductivity at the time of measurements was very high (1667-1755 µS/cm), which can be explained by the high values of iron in spring water (Rogelj *et al.*, 1972). Physical and chemical results revealed that the temperature and conductivity are closely connected: the higher the water temperature, the higher the conductivity. Wetzel & Likens (1991) ascertained that the conductivity increases by about 2 to 3% per 1 °C. At the Medvedje Brdo spring and Terme Čatež thermal spring, pH was about 7 to 8, while at the mineral Rimski vrelec spring and the spring in Pohorje it ranged between 5.5 and 6.5.

The amount of dissolved oxygen in water and the percentage saturation in the mineral Rimski vrelec spring and the thermal spring was extremely low at the time of measurements, which can be explained by the absence of biogen input of oxygen into spring water and high water temperature in the thermal spring. In the Pohorje spring, the amount of dissolved oxygen in water and the percentage saturation was much higher, although the percentage saturation was at the time of measurements below 100%. Only in the Medvedje Brdo spring the amount of dissolved oxygen in water was above 10 mg/l at the time of measurements, while the percentage saturation was above 100%.

Species composition and abundance

Altogether, 83 algal taxa were determined (Tab. 2). Most of them (51) belonged to Bacillariophyceae, 14 to Cyanophyceae, 11 to Chlorophyceae, four to Xanthophyceae, and three to Zygnematophyceae.

38 algal taxa were determined in the Medvedje Brdo spring, 37 in the mineral Rimski vrelec spring, 19 in the Pohorje spring, and 8 in the thermal Terme Čatež spring (Tab. 2). The algal structure by classes in all three waterfalls is shown in figure 2. The most frequent classes of algae in the Medvedje Brdo spring and in the mineral Rimski vrelec spring were Bacillariophyceae, followed by Cyanophyceae and Chlorophyceae. Most common in the Pohorje spring was the class Chlorophyceae, and Cyanophyceae in the thermal Terme Čatež spring.

Tab. 1: Ranges of some physical and chemical parameters in the Medvedje Brdo spring, the Pohorje spring, the mineral Rimski vrelec spring, and the thermal Terme Čatež spring in the 1999, 2000 and 2001. Legend: A – Medvedje Brdo spring, B – Pohorje spring, C – Rimski vrelec mineral spring, D – Terme Čatež thermal spring.
Tab. 1: Obseg nekaterih fizikalnih in kemijskih parametrov v izviru na Medvedjem brdu, izviru na Pohorju, mineralnem izviru Rimski vrelec in termalnem izviru v Termah Čatež v letih 1999, 2000 in 2001. Legenda: A – izvir na Medvedjem Brdu, B – izvir na Pohorju, C – mineralni izvir Rimski vrelec, D – termalni izvir v Termah Čatež.

sampling point	temperature (°C)	conductivity (µS/cm)	pH	oxygen (mg/l)	saturation (%)
A	7.4-10.4	300-450	7.65-8.13	12.0-13.6	107-111
B	7.7-8.7	17-51	5.56-5.70	9.9-12.5	93-97
C	8.5-10.3	1667-1755	6.00-6.44	3.0-5.2	27-45
D	46.4-55.5	457-662	7.10-7.17	1.3-2.3	17-34

Tab. 2: Algal species list with estimation of abundance (1 – single, 3 – customary, 5 – dominate) from the Medvedje Brdo spring, Pohorje spring, Rimski vrelec mineral spring, and Terme Čatež thermal spring in the years 1999, 2000 and 2001 with marked taxa new to Slovenia.
Tab. 2: Vrstna sestava alg z oceno abundance (1 – posamična, 3 – običajna, 5 – prevladujoča) v izviru na Medvedjem brdu, izviru na Pohorju, mineralnem izviru Rimski vrelec in termalnem izviru v Termah Čatež v letih 1999, 2000 in 2001 z označenimi taksoni, ki so novi za Slovenijo.

taxon	Medvedje Brdo spring				Pohorje spring			Rimski vrelec mineral spring				Terme Čatež thermal spring			
	2.4. 99	6.8. 99	17.10. 99	19.2. 00	7.8. 99	16.10. 99	3.6. 00	12.8. 99	20.10. 99	25.2. 00	14.5. 00	28.3. 00	16.9. 00	20.11. 00	15.1. 01
PROKARYOTA															
CYANOPHYTA															
CYANOPHYCEAE															
¤*Calothrix thermalis* (Schwabe) Hansg.												1	1	3	1
Gloeocapsa alpina Naegeli												3	3	3	3
¤*Gloeocapsa bituminosa* (Bory) Kuetz.									1						
Gloeocapsa compacta Kuetz.		1													
Gloeocapsa montana Kuetz.		1													
Gloeocapsa turgida (Kuetz.) Holler.	1	1											1		
Microcystis sp.					1		1								
Oscillatoria sp.		1		1											
Oscillatoria splendida Greville								1	1						
¤*Phormidium angustissimum* W. & G. S. West								1	1			1	1	1	1
Phormidium retzii (Agardh) Gomont	1	1													
Phormidium sp.	1	1	1		1		1			1					
¤*Phormidium valderiae* (Delp.) Geitler								1				3	3	3	1
Pseudanabaena constricta (Szafer) Lauterb.								1	1						
EUKARYOTA															
HETEROKONTOPHYTA															
XANTHOPHYCEAE															
Botryochloris minima Pasch.					1										
Gloeobotrys monochloron Ettl.					5	5	3								
Tribonema minus Hazen									1		5				
Tribonema vulgare Pascher								3	1	3					
BACILLARIOPHYCEAE															
Achnanthes delicatula ssp. *hauckiana* (Grun.) Lan.-Bert.	3	3	1	1											
Achnanthes lanceolata (Breb.) Grun.					1										
Achnanthes lanceolata ssp. *lanceolata* var. *lanceolata* (Breb.) Grun.	1	1	1					5	5	5	5				
Achnanthes minutissima Kuetz.	3	3	1	1				3	1	1	1	1			
Achnanthes sp.			1		1				1						
Amphora ovalis (Kuetz.) Kuetz.	1	1	1					1							
Amphora pediculus (Kuetz.) Grun.	1		1	1											
Aulacoseira granulata (Ehren.) Simon.			1												
Caloneis bacillum (Grun.) Cleve	1	1	1												
¤*Caloneis molaris* (Grun.) Kramm.								1	1	1	1				
Cocconeis placentula Ehren.	3	3	1	3											
Cymbella affinis Kuetz.								1	1	1	1				
Cymbella aspera (Ehren.) Peragallo	1														
Cymbella cymbiformis Agardh								1							
Cymbella helvetica Kuetz.	1	1													
Cymbella silesiaca Bleisch		1													
Cymbella sp.	1														
Denticula tenuis Kuetz.	1	3	1					1	1	1	1				
Diatoma vulgaris Bory							1								
Diploneis oblongella (Naegeli) Cleve-Euler								1	1	1	1				
Ellerbeckia arenaria (Moore) Craw.	1		1	1											
Epithemia adnata (Kuetz.) Breb.			1												
Eunotia bilunaris Ehren.							5								
Eunotia exigua (Breb.) Raben.					1		1								

taxon	Medvedje Brdo spring				Pohorje spring			Rimski vrelec mineral spring				Terme Čatež thermal spring			
	2.4. 99	6.8. 99	17.10. 99	19.2. 00	7.8. 99	16.10. 99	3.6. 00	12.8. 99	20.10. 99	25.2. 00	14.5. 00	28.3. 00	16.9. 00	20.11. 00	15.1. 01
Fragilaria capucina Desm.								3	3	3	3				
Fragilaria fasciculata (Agardh) Lan.-Bert.	1														
Frustulia rhomboides (Ehren.) De Toni													1		
Frustulia vulgaris (Thwait.) De Toni								1	1	1	1				
Gomphonema angustatum (Kuetz.) Raben.	1	1						1			1				
Gomphonema angustum Agardh	3	1	1	1											
Gomphonema clavatum Ehren.		1						3	3	3	3				
Gomphonema gracile Ehren.										1	1				
Gomphonema parvulum Kuetz.								1	1						
Navicula angusta Grun.		1													
¤*Navicula cincta* (Ehren.) Ralfs in Pritchard								1	1						
Navicula contenta Grun.						1									
¤*Navicula gregaria* Donkin								1	1	1	1				
Navicula mutica var. *mutica* Kuetz.		1													
Navicula sp.	1														
Navicula tripunctata (Muell.) Bory	1	1	1	1											
Navicula veneta Kuetz.		1						1	1						
Nitzschia dissipata (Kuetz.) Grun.		1													
Nitzschia fonticola Grun.									1		1				
Nitzschia linearis (Agardh) W.Smith									1		1				
Nitzschia linearis var. *linearis* (Agardh) W. Smith		1	1	1											
Nitzschia palea (Kuetz.) W.Smith								1	1	1	1				
¤*Nitzschia sinuata* var. *delognei* (Grun.) Lan.-Bert.									1	1	1				
¤*Pinnularia sudetica* (Hilse) Peragallo								1	1	1	1				
Surirella linearis W. Smith		1		1											
Surirella sp.	1														
Surirella spiralis Kuetz.		1													
CHLOROPHYTA															
CHLOROPHYCEAE															
Cladophora sp.								1	1	1					
Gloeocystis vesiculosa Naeg.					1										
Klebsormidium flaccidum (Kuetz) Silva, Mattox & Black.					1	1	1	1		1					
¤*Koliella crassa* Hindak					1										
¤*Koliella variabilis* (Nyg.) Hindak					1		1								
Microspora amoena (Kuetz.) Raben.					1	1									
Microthamnion kuetzingianum Naegeli								1	3	1	3				
Oedogonium sp.		1													
Stigeoclonium farctum Berthold						3									
Stigeoclonium tenue (Agardh) Kuetz.								1	1	1	1				
Trentepohlia aurea (L.) Martius	1	3	1	1	1		1		1		1			1	1
ZYGNEMATOPHYCEAE															
Bambusina brebissonii Kuetz.					1										
Mougeotia sp.								1	1	1	1				
Netrium digitus (Ehren.) Itzigs. & Rothe						1									

¤ Algae first recorded in Slovenia

Ecological conditions in thermal springs are more or less constant with very high water temperature; most common in springs of this type is the class Cyanophyceae (Vrhovšek, 1985). Cyanophyceae are most common in various thermal springs worldwide (Doemel & Brock, 1971; Carr & Whitton, 1973; Round, 1973; Noguerol, 1991). As far as other classes of algae are concerned, only Bacillariophyceae are also common in thermal springs (they appeared only when water temperature was below 40 °C) (Cvijan & Blaženčić, 1996). Species from the classes Xanthophyceae and Zygnematophyceae occurred only in the mineral Rimski vrelec spring.

In the mineral Rimski vrelec spring and in the thermal Terme Čatež spring, no seasonal changes were found in the algal communities. In the springs of Med-

vedje Brdo and Pohorje, high species richness was established in summer samples and low in autumn and winter samples.

In all samples of the Medvedje Brdo spring, the following taxa were recorded: *Achnanthes delicatula* ssp. *hauckiana*, *A. minutissima*, *Cocconeis placentula*, *Gomphonema angustum*, *Navicula tripunctata* and *Trentepohlia aurea*, most common amongst which were *A. delicatula* ssp. *hauckiana* and *C. placentula*. In all Rimski vrelec samples, the following taxa were determined: *Achnanthes lanceolata* ssp. *lanceolata* var. *lanceolata*, *A. minutissima*, *Caloneis molaris*, *Cymbella affinis*, *Denticula tenuis*, *Diploneis oblongella*, *Fragilaria capucina*, *Frustulia vulgaris*, *Gomphonema clavatum*, *Navicula gregaria*, *Nitzschia palea*, *Pinnularia sudetica*, *Microthamnion kuetzingianum*, *Mougeotia* sp. and *Stigeoclonium tenue*. The predominant species were *Tribonema minus* and *A. lanceolata* ssp. *lanceolata* var. *lanceolata*. In the mineral Rimski vrelec spring, many species were typical of waters with high level of electrolytes; some of them were typical even of brackish waters *(Gomphonema gracile*, *Navicula cincta*, *N. veneta*, *Nitzschia linearis*, *N. sinuata* var. *delognei),* which can be explained by the high conductivity values (1667-1755 µS/cm) in spring water. Many species were typical of eutrophic waters: *Oscillatoria splendida*, *N. cincta*, *N. veneta*, *G. angustatum*, *G. parvulum*, *N. palea* etc.

Algal community in the Pohorje spring greatly differed from algal communities in the springs of Medvedje Brdo and Rimski vrelec. In all samples from the Pohorje spring, the species *Gloeobotrys monochloron* and *Klebsormidium flaccidum* were recorded. The most frequently found species were *G. monochloron* and *Eunotia bilunaris*. Many species were typical of acid waters: *Netrium digitus*, *Bambusina brebissonii* and *Botryochloris minima*.

The most common species in Terme Čatež spring was *Gloeocapsa alpina*. Species *A. minutissima*, *Frustulia rhomboides* and *Trentepohlia aurea* were also fairly common. Stockner (1967) found out that some diatoms can live at very high water temperatures, although their optimum is below 30 °C. Cvijan (1986), who studied algae in various Serbian thermal springs, established that algae occur in water with temperatures up to 73 °C. At 73 °C, he found only one species of algae in the water – *Phormidium angustissimum*. In all four Terme Čatež periphyton samples, *P. angustissimum* was recorded. In waters with temperature up to 46 °C, *Synechococcus* was often the prevailing genus, while in waters with temperatures up to 57 °C, species of the genus *Phormidium* prevailed. At water temperatures below 46 °C, species of the genus *Calothrix* were prevalent (Stewart, 1970). Noguerol (1991) studied algal flora in hot springs of northwest Spain. He found 15 algal species, with prevailing Cyanophyceae. Cyanophyceae are extremely resistant to high temperatures. Some of them were found even in waters with temperatures up to 85 °C (Round, 1973).

In the four springs, 11 taxa were recorded for the very first time in Slovenia (Tab. 2), eight of these in the mineral Rimski vrelec spring, four in the Pohorje spring, three in the thermal Terme Čatež spring, and two in the Medvedje Brdo spring. Five of the first recorded taxa belonged to Bacillariophyceae, four to Cyanophyceae and two to Chlorophyceae.

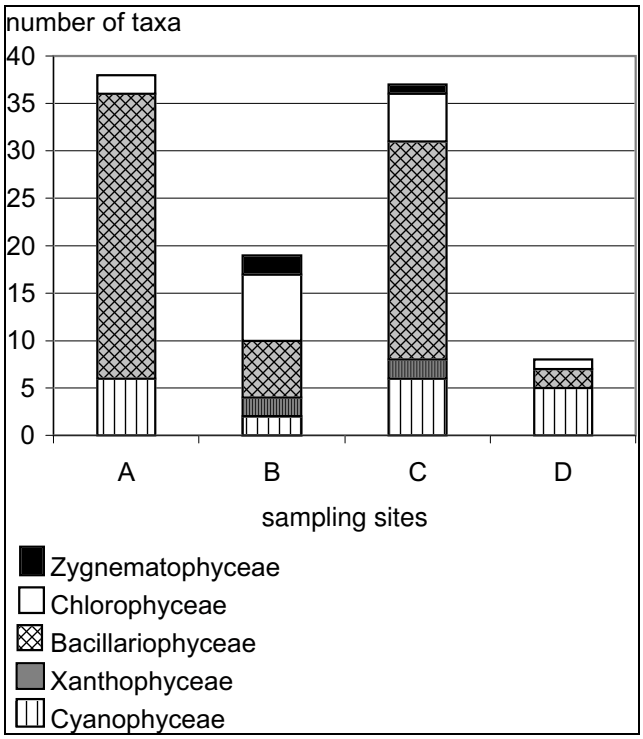

Fig. 2: Algal structure by classes in the Medvedje Brdo spring, Pohorje spring, Rimski vrelec mineral spring, and Terme Čatež thermal spring in the years 1999, 2000 and 2001 Legend: A – Medvedje Brdo spring, B – Pohorje spring, C – Rimski vrelec mineral spring, D – Terme Čatež thermal spring.

Sl. 2: Sestava alg po razredih v izviru na Medvedjem brdu, izviru na Pohorju, mineralnem izviru Rimski vrelec in termalnem izviru v Termah Čatež v letih 1999, 2000 in 2001. Legenda: A – izvir na Medvedjem Brdu, B – izvir na Pohorju, C – mineralni izvir Rimski vrelec, D – termalni izvir v Termah Čatež.

FLORA ALG V ŠTIRIH RAZLIČNIH IZVIRIH V SLOVENIJI

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POVZETEK

V nalogi so bile raziskane perifitonske alge v štirih različnih izvirih v Sloveniji: izviru na Medvedjem Brdu, izviru na Pohorju, mineralnem izviru Rimski vrelec in termalnem izviru v Termah Čatež z namenom ugotoviti abundanco in vrstno sestavo algnih združb v letih 1999, 2000 in 2001. To je prva raziskava alg v naštetih izvirih. V izviru na Medvedjem Brdu, termalnem izviru v Termah Čatež in mineralnem izviru Rimski vrelec so bila opravljena po štiri vzorčenja, v izviru na Pohorju pa tri. V laboratoriju so bili vzorci perifitona pregledani pod svetlobnim mikroskopom. Pri pregledovanju vzorcev so bile ocenjene pogostosti posameznih vrst in podvrst s števili od 1 do 5 (1 – posamična, 3 – običajna, 5 – prevladujoča). Izmerjeni so bili tudi nekateri fizikalni in kemijski dejavniki, ki vplivajo na sestavo in številčnost algnih združb.

Skupno je bilo v vseh štirih izvirih določenih 83 različnih taksonov iz petih razredov alg. Od tega je bilo v izviru na Medvedjem Brdu določenih 38, v izviru na Pohorju 19, v mineralnem izviru Rimski vrelec 37 in v termalnem izviru v Termah Čatež 8 različnih taksonov alg. Po številu taksonov so v izviru na Medvedjem Brdu in v izviru Rimski vrelec prevladovale kremenaste alge, v izviru na Pohorju Chlorophyceae in v termalnem izviru Cyanophyceae.

V vseh štirih izvirih je bilo skupno določenih 11 taksonov, ki so v Sloveniji zabeleženi prvič. Pet taksonov pripada razredu Bacillariophyceae, štiri razredu Cyanophyceae in dva razredu Chlorophyceae. V izviru Rimski vrelec je bilo določenih 8 vrst, v izviru na Pohorju 4, v termalnem izviru v Termah Čatež 3 in v izviru na Medvedjem Brdu 2 novi vrsti.

Ključne besede: alge, perifiton, izviri, termalni izviri

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ALGAE IN MANURE AND WASTEWATER FROM THE CONSTRUCTED BARJE AND DRAGONJA WETLANDS

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ABSTRACT

In 2000 and 2001, samples were taken seasonally in three wastewater types: manure wastewater, wastewater from the constructed Barje wetland, and wastewater from the constructed Dragonja wetland. The purpose of our investigation was to determine species structure and abundance of algae. Altogether, 27 algal species were determined. Most of them belonged to Cyanophyceae. Microcystis hansgirgiana *was recorded for the first time in Slovenia.*

Key words: algae, manure, wastewaters

ALGHE PRESENTI NEL TERRICCIO DI LETAME E NELLE ACQUE DI SCOLO PROVENIENTI DAI DEPURATORI VEGETALI DI BARJE E DRAGOGNA

SINTESI

Abbiamo effettuato una ricerca sulle alghe presenti in tre habitat ipetrofici: terriccio di letame, acqua di scolo del depuratore vegetale (DV) Barje e quella del DV Dragogna. Scopo della ricerca era di identificare la composizione specifica e l'abbondanza relativa delle comunità algali negli anni 2000 e 2001. Nel terriccio di letame e nelle acque di scolo di entrambi i depuratori abbiamo individuato 27 specie algali con una prevalenza di cianobatteri. La specie Microcystis hansgirgiana è *stata individuata in Slovenia per la prima volta.*

Parole chiave: alghe, terriccio di letame, acque di scolo

INTRODUCTION

Manure wastewater is a mixture of animal excretions – excrements and urine (Leskošek, 1993). Undiluted manure contains 90% of water and 10% of dry substance. In manure, some additional water from cleaning the stables can be usually found as well. Constructed wetlands are wastewater treatment systems, where similar processes known from natural wetlands are present (Vrhovšek, 1998). In wastewaters temperature increases, especially in summer, and coupled with available nutrients creates ideal conditions for algae growth. This leads to the phenomenon known as algae bloom (Hancock & Buddhavarapu, 1993). In certain instances, algae blooms die due to environmental conditions such as low temperatures, toxicity problems created by the population, increases in pH, release of toxic metabolites, etc. Dead algae sink to the bottom where their chemical constituents are transformed, solubilized and recycled into the water. This contributes to decreases in oxygen and increases in nutrients such as phosphorus and nitrogen. The fluctuation in the algal growth cycle affects the consistency of the effluent quality of wastewater (Hancock & Buddhavarapu, 1993).

The aim of the current investigation was to find out the species structure and abundance of algae in manure wastewater, wastewater from the constructed Barje wetland and wastewater from the constructed Dragonja wetland in the years 2000 and 2001.

MATERIAL AND METHODS

Samples of algae were taken seasonally in the years 2000 and 2001. Four samples were taken from manure (May 2000, August 2000, November 2000, January 2001), another four wastewater samples from the constructed Barje wetland (April 2000, August 2000, November 2000, January 2001), and three samples from the constructed Dragonja wetland (July 2000, November 2000, January 2001). Samples of manure were taken in the grassland above the manure basin of one of the farms. Samples of wastewater from the constructed Barje wetland were taken from the wastewater accumulation basin, while wastewater samples from the constructed wetland Dragonja were taken in the bed amongst *Phragmites communis* Trin. The samples were scooped into a small vessel. The sampling sites are presented in figure 1. For precise description of sampling sites, see Krivograd Klemenčič (2001).

Algal species were identified by determination keys of Lazar (1960), Starmach (1966, 1972, 1983), Kramer & Lange-Bertalot (1986, 1988), Hindak *et al.* (1978), Cvijan & Blaženčić (1996) and Hindak (1996). The samples were first examined and then preserved in a 4 % formaldehyde solution. All samples were also treated by concentrated HNO_3 to determine the species from class Bacillariophyceae. Relative abundance was estimated with numbers 1, 3 and 5 (1 – single, 3 – customary, 5 – dominant) (Pantle & Buck, 1955).

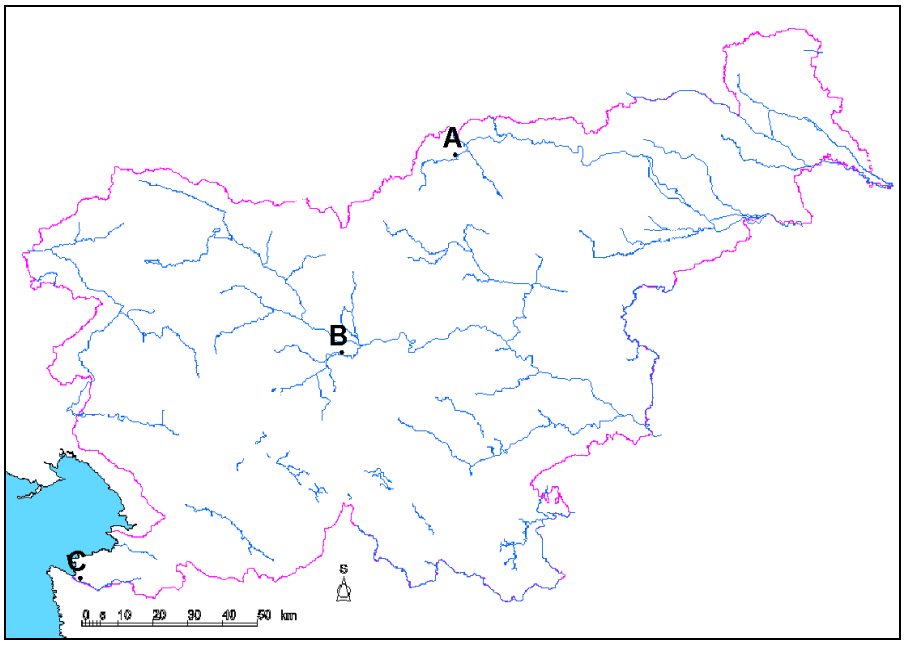

Fig. 1: Map of Slovenia with marked sampling sites. Legend: A – manure, B – constructed Barje wetland, C – constructed Dragonja wetland.
Sl. 1: Zemljevid Slovenije z označenimi vzorčnimi mesti. Legenda: A – gnojevka, B – rastlinska čistilna naprava Barje, C – rastlinska čistilna naprava Dragonja.

RESULTS AND DISCUSSION

Altogether, 27 species of algae were determined (Tab. 1). Most of them (13) belonged to Cyanophyceae, 6 to Bacillariophyceae, 6 to Chlorophyceae and 2 to Euglenophyceae.

12 species of algae were determined in manure, 7 in wastewater from the accumulation basin in the constructed Barje wetland, and 14 in wastewater from the bed amongst *P. communis* in the constructed Dragonja wetland. The algal structure by classes at all three sampling sites is shown in figure 2. The most frequent class of algae in manure and wastewater from the constructed Dragonja wetland was the class of Cyanophyceae. Cyanophyceae were most frequently found in our samples, as revealed by our research into hypertrophic waters (Whitton, 1975; Sedmak & Kosi, 1997). In wastewater from accumulation basin in the constructed Barje wetland, Cyanophyceae were absent, while Bacillariophyceae and Chlorophyceae were prevalent. The main reason for the differences between wastewater samples from both constructed wetlands was probable the sampling site. In the constructed Dragonja wetland, we took samples of algae in wastewater from the bed amongst *P. communis*, while in the constructed Barje wetland we took them from the wastewater accumulation basin. Whitton (1975) established that in phytoplankton of ventilating basins of the wastewater treatment systems Chlorophyceae prevailed, with Cyanophyceae occurring only exceptionally. In manure water, algae from class Euglenophyceae were absent.

In all four manure samples, *Microcystis hansgirgiana* and *Chlorella* sp. were present. *M. hansgirgiana*, *Chlorella* sp. and *Oscillatoria* sp. were the most common species (relative abundance = 3). *M. hansgirgiana* was recorded in Slovenia for the very first time. The most common species among diatoms was *Nitzschia umbonata*, a typical species of eutrophic waters with high values of electrolytes. *N. umbonata* is often found in the outflows of treatment systems (Kramer & Lange-Bertalot, 1988). The number of determined species in manure water between samples did not differ a great deal. The lowest number of species (4) was determined in May 2000.

In all four samples from the constructed Barje wetland, *N. umbonata* and *Chlorella vulgaris* were recorded. *C. vulgaris* was the predominant species (relative abundance = 5).

In all three samples taken in the constructed Dragonja wetland, the following species were determined: *Phormidium* sp., *Euglena* sp., *Navicula veneta* and *N. umbonata*. *N. veneta*, *N. umbonata* and *Oscillatoria tenuis* were the most common species (relativne abundance = 3). In the constructed Dragonja wetland, the number of determined species did not differ much between the seasons, while in the constructed Barje wetland the species diversity was higher in the winter than in the summer samples. Quality of outflow waters during the year is not constant. Outflow waters are most toxic in the summer (dry season) (Bulc, 1998). Changes in the quality of outflow waters have a great impact on the quantitative and qualitative structure of algal association (Bulc, 1998).

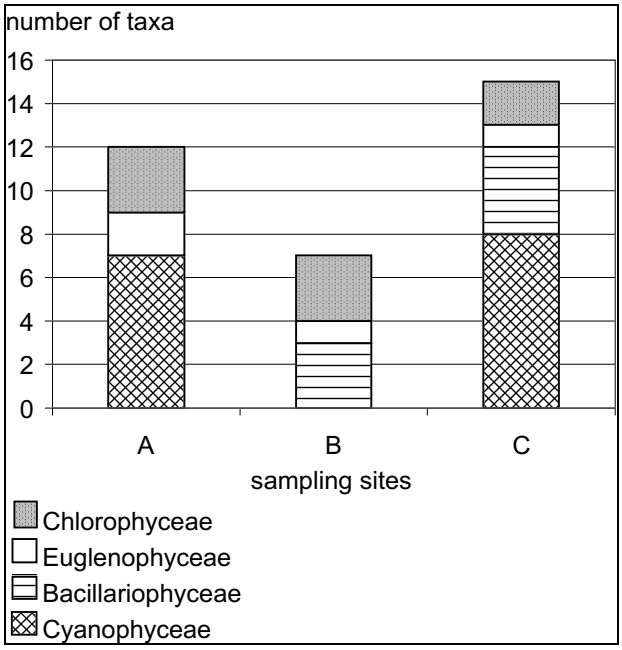

Fig. 2: Algal structure by classes in manure and wastewater from the constructed Barje and Dragonja wetlands in the years 2000 and 2001. Legend: A – manure, B – wastewater from the constructed Barje wetland, C – wastewater from the constructed Dragonja wetland.
Sl. 2: Sestava alg po razredih v gnojevki in odpadni vodi iz rastlinskih čistilnih naprav Barje in Dragonja v letih 2000 in 2001. Legenda: A – gnojevka, B – odpadna voda iz rastlinske čistilne naprave Barje, C – odpadna voda iz rastlinske čistilne naprave Dragonja.

CONCLUSIONS

Altogether, 27 species of algae were determined. Most of them (13) belonged to Cyanophyceae, 6 to Bacillariophyceae, 6 to Chlorophyceae, and 2 to Euglenophyceae. 12 species were determined in manure, 7 in wastewater from the constructed Barje wetland, and 14 in wastewater from the constructed Dragonja wetland. The most frequent classes of algae were Cyanophyceae in manure and wastewater from the constructed Dragonja wetland, and Bacillariophyceae and Chlorophyceae in wastewater from the constructed Barje wetland. In manure, the species *M. hansgirgiana* was determined, which was the first record for Slovenia.

Tab. 1: Algal species list with estimation of abundance (1 – single, 3 – customary, 5 – dominant) in manure and wastewater from the constructed Barje and Dragonja wetlands in the years 2000 and 2001. Legend: A – manure, B – wastewater from the constructed Barje wetland, C – wastewater from the constructed Dragonja wetland.
Tab. 1: Vrstna sestava alg z oceno abundance (1 – posamična, 3 – običajna in 5 – prevladujoča) v gnojevki in odpadni vodi iz rastlinskih čistilnih naprav Barje in Dragonja v letih 2000 in 2001. Legenda: A – gnojevka, B – odpadna voda iz rastlinske čistilne naprave Barje, C – odpadna voda iz rastlinske čistilne naprave Dragonja.

taxon	Sampling site		
	A	B	C
PROKARYOTA			
CYANOPHYTA			
CYANOPHYCEAE			
Gloeocapsa sp.			1
**Microcystis hansgirgiana* (Hansgirg) Elenkin	3		
Oscillatoria agardhii Gomont	1		
Oscillatoria beggiatoiformis (Grün.) Gom.			1
Oscillatoria sp.	3		
Oscillatoria subbrevis Schmidle			1
Oscillatoria tenuis Agardh	1		3
Phormidium sp.	1		1
Pseudanabaena constricta (Szafer) Lauter.			1
Rhabdoderma lineare Schm. In Lauter.	1		
Synechococcus cedrorum Sauvageau	1		
Synechococcus elongatus Naegeli			1
Synechocystis aquatilis Sauvag.			1
EUKARYOTA			
HETEROKONTOPHYTA			
BACILLARIOPHYCEAE			
Amphora coffeaeformis (Agardh) Kütz.			1
Cymbella silesiaca Bleisch		1	
Navicula sp.	1	3	
Navicula veneta Kütz.			3
Nitzschia sp.			1
Nitzschia umbonata (Ehren.) Lan.-Bert.	1	1	3
EUGLENOPHYTA			
EUGLENOPHYCEAE			
Euglena sp.			1
Euglena viridis Ehren.		1	
CHLOROPHYTA			
CHLOROPHYCEAE			
Chlamydomonas ehrenbergii Gorosch.		3	
Chlamydomonas sp.	1		1
Chlorella sp.	3		
Chlorella vulgaris Beyer.		5	
Klebsormidium flaccidum (Kütz) Silva, Mattox & Black.		1	
Trentepohlia aurea (L.) Martius	1		1

* species recorded in Slovenia for the first time

ALGE V GNOJEVKI IN ODPADNI VODI IZ RASTLINSKIH ČISTILNIH NAPRAV BARJE IN DRAGONJA

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POVZETEK

V nalogi smo raziskovali alge v treh hipertrofnih habitatih: gnojevki, odpadni vodi v rastlinski čistilni napravi (RČN) Barje in odpadni vodi v RČN Dragonja. Namen raziskave je bil ugotoviti kvalitativno vrstno sestavo in relativno abundanco algnih združb v letih 2000 in 2001. V gnojevki in v odpadni vodi v RČN Barje smo opravili po štiri vzorčenja, v odpadni vodi v RČN Dragonja pa tri. V laboratoriju smo vzorce alg pregledali pod svetlobnim mikroskopom. Pogostost posameznih vrst alg smo ocenili s števili 1, 3 in 5 (1 – posamična, 3 – običajna in 5 – prevladujoča).

Skupaj smo v gnojevki in v odpadnih vodah iz obeh RČN določili 27 različnih vrst iz štirih razredov alg. V gnojevki smo določili 12, v RČN Barje 7 in v RČN Dragonja 14 različnih vrst alg. Po številu vrst so v gnojevki in v RČN Dragonja prevladovale cianobakterije. V RČN Barje se cianobakterije niso pojavljale, prevladovale so kremenaste in zelene alge. Glavni razlog za razlike med vzorci iz obeh RČN je bilo verjetno različno mesto vzorčenja. V RČN Dragonja smo vzorčili alge v odpadni vodi v gredi med trstičjem, v RČN Barje pa v odpadni vodi v akumulacijskem bazenu.

V gnojevki smo v vseh štirih vzorcih zabeležili vrsti Microcystis hansgirgiana *in* Chlorella *sp., ki sta bili tudi med najbolj pogostimi vrstami. V RČN Barje sta se v vseh štirih vzorcih pojavljali vrsti* Nitzschia umbonata *in* Chlorella vulgaris. C. vulgaris *je bila prevladujoča vrsta. V RČN Dragonja so bile v vseh treh vzorcih ugotovljene vrste* Phormidium *sp.,* Euglena *sp.,* Navicula veneta *in* N. umbonata. N. veneta, N. umbonata *in* Oscillatoria tenuis *so bile najbolj pogoste vrste.* M. hansgirgiana *je v Sloveniji prvič zabeležena vrsta.*

Ključne besede: alge, gnojevka, odpadne vode

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THE ASSOCIATION *GENTIANO TERGLOUENSIS-CARICETUM FIRMAE* T. WRABER 1970 IN THE KRN MOUNTAINS (THE JULIAN ALPS)

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ABSTRACT

The syntaxonomy and ecology of the Carex firma *stands in the Krn Mts. (eastern Julian Alps) are presented by applying the sigmatistic method and cluster analysis. The researched stands are classified in the association* Gentiano terglouensis-Caricetum firmae *T. Wraber 1970 and are further subdivided into three subassociations:* -dryadetosum octopetalae *Poldini & Feoli 1976,* -drepanocladetosum uncinati *subass. nova and* -potentilletosum nitidae *subass. nova.*

Key words: phytosociology, phytogeography, endemic species, *Elyno-Seslerietea*, *Caricion firmae*, *Caricetum firmae*, Southeastern Calcareous Alps

L'ASSOCIAZIONE *GENTIANO TERGLOUENSIS-CARICETUM FIRMAE* T. WRABER 1970 SUL MASSICCIO DEL MONTE NERO (ALPI GIULIE)

SINTESI

Mediante il metodo sigmatista e l'analisi a grappolo, l'autore presenta la sintassonomia e l'ecologia delle formazioni a Carex firma *sul massiccio del Monte Nero (Alpi Giulie orientali). Le formazioni studiate sono distribuite nelle comunità* Gentiano terglouensis-Caricetum firmae *T. Wraber 1970 e quindi distribuite in tre subassociazioni:* -dryadetosum octopetalae *Poldini & Feoli 1976,* -drepanocladetosum uncinati *subass. nova e* -potentilletosum nitidae *subass. nova.*

Parole chiave: fitosociologia, fitogeografia, specie endemiche, *Elyno-Seslerietea*, *Caricion firmae*, *Caricetum firmae*, Alpi calcaree sud-orientali

INTRODUCTION

The first review of the botanical research carried out in the Julian Alps that also embraced floristic activity in the Krn Mts. was prepared by Wraber (1969). Subsequently, botanical activity was presented by Dakskobler for the Upper Soča Valley (Dakskobler, 1997) and again by Wraber for the wider area of Triglav National Park (Wraber, 2001), while Surina & Vreš (2003) recently collected data on the botanical research carried out to date on Mt. Lemež. A more detailed review of the botanical research for the Krn Mts. was prepared by Surina (2004).

The knowledge about the subalpine and alpine vegetation of the Krn Mts. is still poor in comparison with the knowledge about its flora. It has mainly been studied by T. Wraber and I. Dakskobler. In the first overall phytosociological study of the vegetation of rocky crevices and screes in the Julian Alps, Wraber (1972) made five relevés of the association *Festucetum laxae* (Aichinger 1933) Wraber 1970, two at Jezero v Lužnici and three at Krnsko jezero. He discovered *Bupleurum longifolium*, so far known only from Mt. Nanos, at the end of the Krn-Srednji vrh-Krnčica ridge on the northern slope of the peak Vršič, and thus made the relevé of the stand – *Salicetum waldsteinianae* Beger 1922 corr. Zupančič & Žagar 2001 (Wraber, 1980). In the context of his paper on phytosociological conditions of the species *Minuartia rupestris* in the Julian Alps, he also made three relevés on Mt. Rdeči rob (Wraber, 1986) and described a new association of rocky crevices in the Julian Alps – *Paederoto luteae-Minuartietum rupestris* Wraber 1986. The discovery of *Viola cornuta* on Mt. Lemež was surprising and phytogeographically important (found by forest engineer Ivan Veber), which gave rise to an individual paper in which Wraber (1995) discussed its origin in details, as well as provided a thorough phytosociological assessment (a relevé) of the site (*Caricetum ferrugineae* Lüdi 1921 s. lat.).

Since 1990s, Dakskobler has been active on this floristically very rich and phytogeographically exciting southern edge of the Julian Alps. He has contributed a whole series of interesting novelties to the knowledge of the flora and vegetation of the Soča Valley and its surroundings. In a paper on the flora of the southern Julian Alps and its foothills he reported, among other things, on the find of the species *Asplenium seelosii* southeast of Mt. Veliki Kuntar, where he also supplemented the relevé of the site and classified it in the association *Potentillo clusianae-Campanuletum zoysii* Aichinger 1933 (Dakskobler, 1994). In 2000, he published a paper in which he thoroughly examined the phytosociological and environmental conditions of growth sites of the stenoendemic species *Moehringia villosa* (Dakskobler, 2000). In a detailed review of all sites known to date, he also stated, for the Krn Mts., the peak Palec above Lašca pasture, Mt. Rdeči rob above Ovčje medrje and Slemenske peči by Snegova grapa gorge. Altogether he made seven relevés at the aforementioned locations belonging to the newly described association *Campanulo carnicae-Moehringietum villosae* Dakskobler 2000 (Dakskobler, 2000). The excellent find of *Paradisea liliastrum* below the Krnčica ridge was first publicly presented in a popular paper, and eventually also in an original scientific paper (Dakskobler, 2001a, b). In establishing the succession stands with overgrowing hayfields in former habitats of subalpine beech forests *Polysticho lonchitis-Fagetum* (Horvat 1938) Marinček in Poldini & Nardini 1993, he made two relevés on the southern slope of Mt. Lemež, which were classified in the association *Centaureo haynaldii-Laserpitietum sileri* Dakskobler 2003 prov. and one below the peak Debeljak by Krasji vrh in the pioneer spruce forest *Adenostylo glabrae-Piceetum* M. Wraber ex Zukrigl 1973 corr. Zupančič 1993 var. geogr. *Cardamine trifolia* Zupančič 1999 subvar. geogr. *Luzula nivea* Zupančič 1999 *betonicetosum alopecuri* Dakskobler 2003 (Dakskobler, 2003b). Surina and Vreš again initiated, with their discovery of three new localities of *Viola cornuta* between Mt. Lemež, peak Debeljak and Krnsko jezero, a discussion on the origin of its appearance in the Julian Alps, and with three relevés (*Caricetum ferrugineae* s. lat. – southwest slope of Debeljak, *Avenastro parlatorei-Festucetum calvae* (Aichinger 1933 corr. Franz 1980) Poldini & Feoli Chiapella in Feoli Chiapella & Poldini 1993 – the Škrbina pass and a relevé on a nitrophilous habitat in a small basin by lake Krnsko jezero) also researched the phytosociological characteristics of the sites (Surina & Vreš, 2003). In 2002 and 2003, B. Surina studied the subalpine and alpine vegetation of the Krn Mts. (Surina, 2004); the aim of this paper is thus to present some of the results of phytosociological research of the stands with predominating *Carex firma*.

The published phytosociological data on the *Carex firma* stands in the Julian Alps are indeed scarce. The next inventory of the *Carex firma* stands in the Julian Alps in addition to Wraber's inventory from Mt. Jalovec and his synoptic table (1970), was only recently contributed by Dakskobler, who carried out a research into the phytosociological characteristics of a *Carex rupestris* site in the vicinity of Mt. Črna prst and temporarily classified the relevé in the association *Gentiano terglouensis-Caricetum firmae* (Dakskobler, 2003a). In the Karavanke Mts. (partly also in the Kamnik-Savinja Alps), Aichinger (1933) provided grounds for the association *Gentiano-Caricetum* with two phytosociological tables, while Haderlapp (1982) and Seliškar (1993) provided them in the Kamnik-Savinja Alps. In the Carnic Alps, Poldini & Feoli (1976) studied the association's phytosociology and ecology, while Wikus (1960) studied them in the Lienz Dolomites.

MATERIAL AND METHODS

Studied area

The Krn massif is the extreme western edge of the eastern Julian Alps (Fig. 1). It is surrounded on almost all sides by the valley of the Soča river and its tributaries, the rivers of Tolminka and Lepenica: to the north and northeast it is bounded by the Bovec basin and the Lepena valley, to the west and south by the Soča valley, and to the southeast by the Tolminka valley. Towards the east, the relief boundary is not so sharp; it is divided from the Komna plateau by a north-south mountain ridge from Velika Baba (2008 m) above the Lepena valley, Lanževica (2003 m) to Mahavšček (Veliki Bogatin, 2008 m) above the Tolminka valley. Two larger and two smaller crests and the group of mountains around Krnsko jezero stand out in the massif. The crests are not uniform and are broken here and there by smaller or larger passes ("škrbina"). Thus, in the longest ridge, between the peaks of Vršič and Lipnik above the Tolminka valley in the ridge in addition to the Krnska and Batogniška škrbina, more important passes or steps are Vratca (around 2000 m) between the peaks of Lopatnik and Krnčica and Lužnica valley (around 1750 m), which is surrounded by the peaks of Maselnik, Škofič and Mt. Rdeči rob. The highest mountains on the ridge are Krn (2244 m), Batognica (2164 m), Krnčica (2142 m) and Srednji vrh (2134 m). The other major mountain chain, the deeply indented Polovnik ridge, is situated in the bend of the Soča river, climbing steeply and in places precipitously above the Soča valley from the northwest towards the southeast between the villages of Log Čezsoški and Drežniške Ravne.

On the rock basis predominates the Upper Triassic stratified Dachstein limestone. Between the light grey Upper Triassic Dachstein limestone, deposits of the Upper flat micrite platy and calcarenite limestone of Volče with chert stand out from afar due to their characteristic reddish colour. They are particularly well seen on Mt. Rdeči rob, the stony edge between Lužnica and Peski, the eastern slope of Mt. Batognica and on the ridge between the Vogel and Lemež Mts. (Buser, 1986, 1987).

Because of the prevailing carbonate bedrock, the Krn massif is strongly karstified, especially in some places. It is a typical high mountain karst world, with broken relief or numerous sink-holes, swallow holes, basins, abysses and caves. Glacial lakes, like the largest ones – Krnsko jezero, Dupeljsko jezero and Jezero v Lužnici – are found in sink-holes and at the dry valleys' bottoms. From a geotectonic aspect, the Krn massif is part of the Outer Dinarides, cutting into the Inner Dinarides with its southern edge.

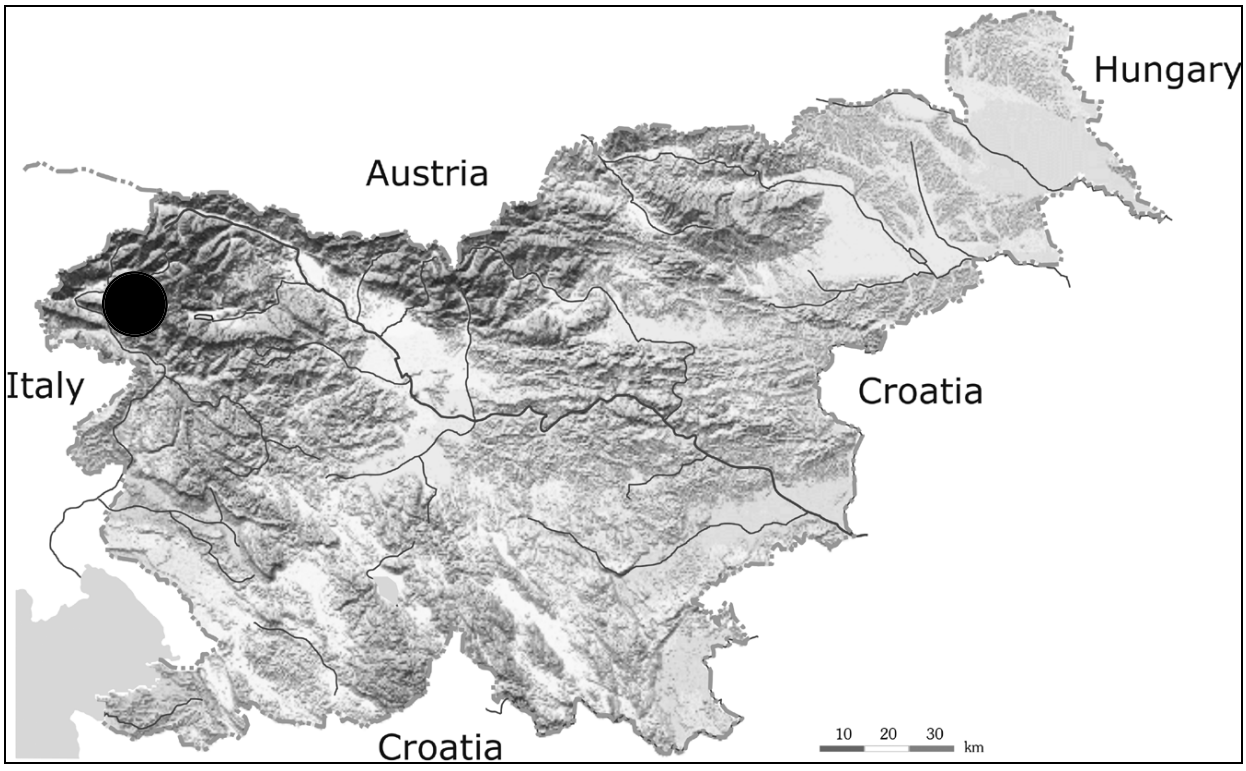

Fig. 1: Krn Mts. in the Julian Alps.
Sl. 1: Krnsko pogorje v Julijskih Alpah.

The Krn Mts. have Alpine climate. Because of the vicinity of the Mediterranean and the exposed position, the Krn massif is known for one of the highest amounts of rainfall in Slovenia. In the nearest and comparable meteorological station at Dom na Komni (1520 m), 2934 mm of rainfall annually was measured in the 1961-1991 period and a mean annual temperature of 3.7 °C (Mekinda-Majaron, 1995; Zupančič, 1995).

The entire area is distinctly characterized by traces of the intense military activities from the First World War I, for this was the area of the Soča Front (Isonzo Front) during the years 1915 and 1917.

Methods

Phytosociological research of the *Carex firma* stands was conducted by applying the sigmatistic method (Braun-Blanquet, 1964). Two indices were calculated for each taxon while we first performed a linear transformation of coverage values for individual taxa (van der Maarel, 1979): (a) coverage index (I_c) according to Lausi *et al.* (1982), and (b) a share of coverage ($D_{\%}$), using the following formula:

$$D_{\%} = \sum_{1}^{n} \frac{c_i}{c_{sum}} 100$$

n – number of relevés in the phytosociological table

c_i – coverage value of registered taxa

c_{sum} – sum of coverage values of all taxa in the phytosociological table (Tab. 1)

With the aid of the computer programme SYN-TAX (Podani, 1993) and extensive synoptic phytosociological table, comparisons with similar stands from the Alps and Dinaric mountains were made.* The measure of dissimilarity was the complement of the "similarity ratio" coefficient. We used the Furthest neighbour – Complete linkage clustering method (CL), Minimization of Increase of Error Sum of Squares (MISSQ) and the ordination method of Principal Coordinates Analysis (PCoA). Groups of diagnostic species were formed on the basis of our own criteria, but with regard to numerous authors. The floristic composition of the researched stands was also analysed according to chorological groups and Raunkiaer's plant life forms. Here we followed the Chorological Atlas of Vascular Plants in the Friuli-Venezia Giulia region (Poldini, 1991). Nomenclature sources for phanerogams are Register of the Flora of Slovenia (Trpin & Vreš, 1995) as well as some supplements in the Mala flora Slovenije (Martinčič *et al.*, 1999).

* Synoptic phytosociological table is available from the author.

RESULTS AND DISCUSSION

Floristic composition of stands

The edificator and one of the characteristic species of the association is *Carex firma*$^{1-5}$ (I_c=85), which appears with the greatest constancy and cover values. Other characteristic species of the association are *Phyteuma sieberi*$^{+-1}$ (I_c=21), *Helianthemum alpestre*$^{+-2}$ (I_c=21), *Crepis kerneri*$^{+}$ (I_c=12), *Saussurea pygmea*$^{+-1}$ (I_c=6), *Chamorchis alpina*$^{+}$ (I_c=2) and *Saxifraga caesia*$^{+}$ (I_c=1), of which only the first appears in more than half of the inventories. Differential species and some characteristic species of the contrasting Central Alpine association *Caricetum firmae* Lüdi 1911 are *Pedicularis rostratocapitata*$^{+-1}$ (I_c=15), *Saxifraga squarrosa*$^{+-1}$ (I_c=14), *Sesleria sphaerocephala*$^{+-2}$ (I_c=12), *Achillea clavenae*$^{+}$ (I_c=9) and *Gentiana terglouensis*$^{+}$ (I_c=5). Species of the association *Caricion austroalpinae* Sutter 1962 occur only rarely in these stands, namely *Koeleria eriostachya, Linum julicum, Laserpitium peucedanoides, Senecio abrotanifolius* and *Trifolium noricum*. The highest number of species in the association concerns to the alliance *Caricion firmae* Gams 1936 (order *Seslerietalia albicantis* Oberd. 1978 corr. Oberd. 1990 and the class *Elyno-Seslerietea* Br.-Bl. 1948), in which only *Dryas octopetala*$^{+-5}$ (I_c=44), *Aster bellidiastrum*$^{+-1}$ (I_c=18) and *Sesleria albicans*$^{+-3}$ (I_c=19) were recorded in more than half of the relevés. *Gentiana clusii, Leontopodium alpinum, Anthyllis vulneraria* subsp. *alpestris* and *Ranunculus hybridus* are additionally more common. Scree species (class *Thlaspietea rotundifolii* Br.-Bl. 1948) are well established in habitats in which succession development has gradually led from scree syntaxa through stands of *Dryas octopetala* to *Carex firma* (*Caricetum firmae* s. lat.), *e.g., Athamanta cretensis* (I_c=7), *Leontodon hispidus* subsp. *hyoseroides* (I_c=6), *Campanula cohleariifolia* (I_c=11), *Soldanella minima* (I_c=8) and *Ranunculus traunfellneri* (I_c=10). Rockier habitats with steeper incline suit species occurring in rock crevices (*Asplenietea trichomanis* [Br.-Bl. in Meier & Br.-Bl. 1934] Oberdorfer 1977, *Potentilletalia caulescentis* Br.-Bl. and Meier & Br.-Bl. 1926), namely *Potentilla nitida* (I_c=14), *Primula auricula* (I_c=6), *Valeriana saxatilis* (I_c=17), *Saxifraga crustata* (I_c=12), *Viola biflora* (I_c=10), *Campanula zoysii, Paederota lutea* and *Petrocallis pyrenaica* (the last three with I_c=3). We recorded *Rhodothamnus chamaecistus*$^{+-3}$ (*Erico-Pinetea*), with a degree of constancy IV, and in half of the relevés the species *Selaginella selaginoides*$^{+-1}$, *Tofieldia calyculata*$^{+-2}$ and *Rhododendron hirsutum*$^{+-2}$. The floristic composition of the association is given in Table 1.

Phanerogams cover from 40 to 100% of the sites (the mean value is 90%). The moss layer in general does not cover a major area of the sites; the mean value is 1% (minimum 0 and maximum 20%), but it is well established in some *Carex firma* stands and reaches a mean

value of 20% (see Table 1, rel. 7-13). The species *Oncophorus virens*$^{+\cdot1}$ and *Drepanocladus uncinatus*$^{+\cdot3}$ are established there with greater constancy and large cover values.

Hemicryptophytes predominate (Tab. 2), around 20 % of the relevé areas being covered by chamaephytes, which indicates the unfavourable habitat conditions. Phanerophytes cover around 10% of the relevé areas, while the share of the relevé areas covered by geophytes and therophytes is low.

Tab. 2: Plant life forms spectrum in the association *Gentiano terglouensis-Caricetum firmae* ***in the Krn Mts. (the Julian Alps).***
Tab. 2: Biološki spekter asociacije *Gentiano terglouensis-Caricetum firmae* ***v Krnskem pogorju (Julijske Alpe).***

abs. No.					Σ	$D_{\%}$				
Fa	Ha	He	Ge	Te		Fa	Ha	He	Ge	Te
12	32	93	6	8	**151**	9	23	63	4	2

Ecology, variability and sindynamics of the stands

Carex firma is dominant in most associations of the alliance *Caricion firmae*. It is a very long-lived species and creates populations at sites due to its own clones. These gradually completely overgrow the sites, making the specific individuals no longer recognisable. Because of its longevity and gradual decay of the plants'ground parts, a layer of humus slowly accumulates under the turfs of *Carex firma* (in Schroeter, 1926). In the case in which the turfs in stands remain close-packed, friable rendzina can develop and gradual acidification occurs during further development of the soil due to the reaction of the soil basis and organic material, which is shown in the floristic composition with the establishment and final predominance of heathers (*Arctostaphyllos alpina, Vaccinium gaultherioides, V. vitis-idaea, Loiseleuria procumbens, Empetrum hermaphroditum* and others) or a succession development towards the associations *Empetro-Vaccinietum gaultherioidis* Br.-Bl. in Br.-Bl. & Jenny 1926 corr. Grabherr 1993 or the association *Loiseleurio-Cetrarietum* Br.-Bl. & al. 1939 (both from the class *Loiseleurio-Vaccinietea* Grabherr 1993). Lüdi's conclusion that the species *Carex firma* creates humus certainly applies, although it does not thrive well in it (Lüdi 1911, in Schroeter, 1926). Together with *Dryas octopetala, Carex firma* plays, among other things, an important role in the stabilisation of screes, which can also be frequently observed in the Krn Mts.

The stands of the association *Gentiano terglouensis-Caricetum firmae* prefer shady and northern exposition (Fig. 2) in the subalpine and alpine belt. The median altitude value of relevés in the Krn Mts. is 1910 m (maximum 2120 m), whereby the lowest relevé was made at an altitude of 1330 m. This was a relevé at a growth site in which a special form of *Carex firma* stands had been created after a long successional development of vegetation from scree to grassland. Areas covered by the stands are in principle small (mean value is 4, minimum 1 and maximum 25 m^2). Exceptionally, there are connected areas larger than 100 m^2, such as on the saddle between the peaks of Mali Peski and Vrh nad Peski, where sheep have almost totally grazed the *Carex firma* turfs.

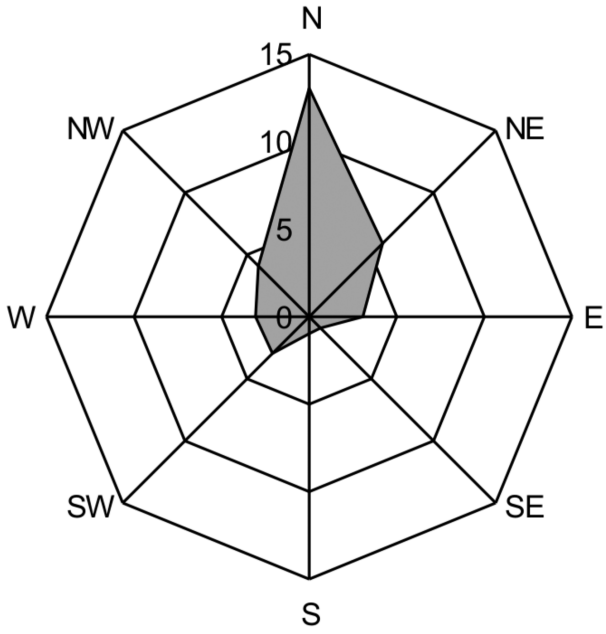

Fig. 2: Exposition of stands of the association *Gentiano terglouensis-Caricetum firmae* ***in the Krn Mts. (the Julian Alps).***
Sl. 2: Ekspozicija sestojev asociacije *Gentiano terglouensis-Caricetum firmae* ***v Krnskem pogorju (Julijske Alpe).***

We made 28 relevés and recorded 151 taxa, a minimum of 12 and maximum of 58 per relevé (the mean value is 28.5) The coefficient of variation is relatively high – 38%. A lack of floristic homogeneity of the association is probably the result of different growth sites in which *Carex firma* stands have been established. Where stands have formed, after gradual successions, on former screes, scree species are more frequent and they reach higher coverage indices. Much the same applies to the stands in rocky crevices, where plants from the class *Asplenietea trichomanis* are more frequent (Fig. 3). On the basis of diagnostic species and with the aid of numerical analysis of the association's stands, we thus divided the association into lower syntaxonomic units, which are well distinguished between themselves both floristically and ecologically (Fig. 3).

Relevés at sites with lengthy snow cover, which are therefore colder and wetter, were classified in the subassociation *Gentiano-Caricetum drepanocladetosum uncinati* subass. nova (Fig. 3, rel. 7-13). It is well marked by the presence and greater cover values of species of the snow-bed vegetation on a calcareous bedrock (*Soldanello-Salicion retusae* Englisch 1999, *Arabidetalia caeruleae* Rübel ex Br.-Bl. 1949), *e.g., Festuca nitida*$^{+-2}$, *Polygonum viviparum*$^{1-2}$, *Geranium argenteum*$^{+-2}$, *Oncophorus virens*$^{+-1}$ and *Drepanocladus uncinatus*$^{+-3}$. The enumerated moss species are good indicators of fresh and damp sites. The moss layer covers the major share of the surface of the habitats in this subassociation.

The holotype of the subassociation *Gentiano terglouensis-Caricetum firmae drepanocladetosum uncinati* subass. nova is the relevé No. 8 in Table 1, *holotypus* hoc loco.

Everything indicates that stands of this subassociation are the result of a successional transition from the snow-bed vegetation (*Soldanello-Salicion retusae*) or the associations *Homogyno discoloris-Salicetum retusae* Aichinger 1933 or *Salici retusae-Geranietum argentei* Surina 2004 to the stands of the association *Gentiano terglouensis-Caricetum firmae* s. lat. (Fig. 3).

In shady habitats with mean values of inclination around 35 °, where turfs of *Carex firma* are not completely linked (phanerogams cover from 40-80 % of the relevé areas), we noticed stands in which a rocky crevice species *Potentilla nitida*$^{2-3}$ predominates. In addition, *Oxytropis jacquinii*$^{+-1}$, *Primula auricula*$^{+}$, *Campanula zoysii*$^{+}$, *Paederota lutea*$^{+}$ and *Petrocallis pyrenaica*$^{+}$ are abundant, which are also differential species of the new subassociation *potentilletosum nitidae* subass. nova. In this subassociation, with the exception of the species

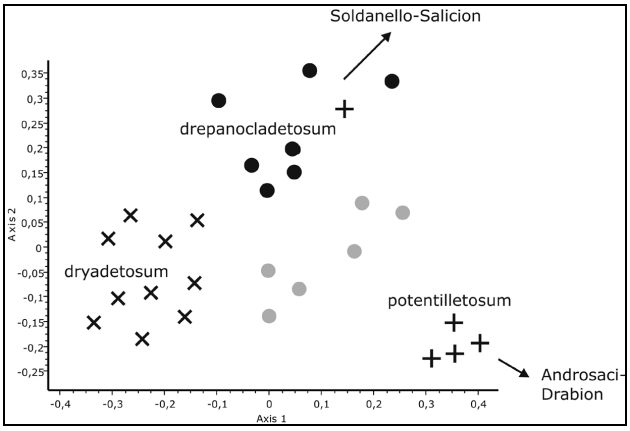

Fig. 3: Two-dimensional scatter diagram of relevés of the association *Gentiano terglouensis-Caricetum firmae* ***from Krn Mts. (the Julian Alps; PCoA, simliarity ratio).***
Sl. 3: Dvorazsežni ordinacijski diagram sestojev asociacije *Gentiano terglouensis-Caricetum firmae* ***v Krnskem pogorju (Julijske Alpe, PCoA, podobnost).***

Campanula cochleariifolia, species of the class *Thlaspietea rotundifolii* are poorly represented, which was indeed expected: stands of the subassociation *potentilletosum nitidae* are in contact with the subalpine and alpine stands of vegetation of rocky crevices and subalpine and alpine grasslands or the associations *Potentilletum nitidae* and *Gentiano terglouensis-Caricetum firmae* (Fig. 3).

The holotype of the subassociation *Gentiano terglouensis-Caricetum firmae potentilletosum nitidae* subass. nova is the relevé No. 18 in Table 1, *holotypus* hoc loco.

The relevés 19-28 (Tab. 1) are floristically most impoverished (the mean number of species per relevé is 19.5). This is mainly the result of a complete dominance of *Carex firma*$^{2-5}$ and *Dryas octopetala*$^{1-5}$, which on habitats with close-knit or joined turfs prevent other plants from thriving. The presence of a larger number of species of the class *Thlaspietea rotundifolii* in the stands of *Carex firma*, *e.g., Crepis kerneri*$^{+}$ (characteristic species of the association, which was observed almost exclusively in this form), *Athamanta cretensis*$^{+-1}$, *Leontodon hispidus* subsp. *hyoseroides*$^{+-1}$ and *Ranunculus traunfellneri*$^{+-1}$, indicate the sindynamical connection of scree syntaxa with stands of subalpine and alpine grasslands (Fig. 3). Actually, in many cases these are *Carex firma* stands which, after prior stabilisation of screes with *Dryas octopetala,* have developed on more or less stabilised screes *(e.g.* relevé No. 19, which we performed very low, 1330 m). *Dryas octopetala* has an important role here, for it creates more favourable conditions for other species to thrive. On the other hand, this form appears exclusively in shady and cooler habitats (northern exposures predominate – see Table 1) with long-lasting snow cover. Poldini & Feoli (1976) noticed similar stands of *Carex firma* with *D. octopetala* in the Carnic Alps. From the syntaxonomic and sindynamic point of view, we followed the authors who classified them in the subassociation *dryadetosum octopetale* Poldini & Feoli 1976.

The relevés 1-5 do not show particular floristic and environmental differentiation, so we have not typologically divided them further.

Geoelements

In terms of the number of species (42) and coverage index (I_c=219), the Mediterranean-montane geoelement predominates in stands (Tab. 3). Of all the syntaxa observed in the Krn Mts., most of the species, 23 (I_c=148), belong to the Arctic-Alpine geoelement of the association under discussion. There was also a large number of species of the East-Alpine geoelement (13; I_c=100) and, together with the association *Ranunculo hybridi-Caricetum sempervirentis* Poldini & Feoli Chiapella in Feoli Chiapella & Poldini 1993, most are in the class

Tab. 3: Chorological groups and coverage indices (I_c) of phanerogams in the association *Gentiano terglouensis-Caricetum firmae* ***in the Krn Mts. (the Julian Alps).***
Tab. 3: Horološke skupine in indeksi pokrovnosti (I_c) fanerogamov v asociaciji *Gentiano terglouensis-Caricetum firmae* ***v Krnskem pogorju (Julijske Alpe).***

Number of taxa / Σc_i													
koz-mop	cirkum bor	paleo-temp	euro-sib	euro-asi	euri-med	arct-alp	alp-karp	europ	alp	med-mont	E-alp	N-ilir	ende-mits
2/2	9/31	1/1	4/7	8/37	1/2	23/148	3/24	8/54	10/54	42/219	13/100	11/40	12/55

Elyno-Seslerietea. Within the framework of the same class, we also recorded the largest number of endemic species in the association *Gentiano terglouensis-Caricetum firmae* (12; I_c=55); 11 species (I_c=40) belong to the Northern-Illyrian geoelement, 10 (I_c=54) to the Alpine, nine species to the Circumboreal geoelement (I_c=31), and eight each to the European (I_c=54) and European-Asian (I_c=37) geoelements. The number of species by geoelements and their coverage indices are shown in Table 3.

Distribution of the association and syntaxonomical position of the stands

Braun-Blanquet (1926) drew attention to the floristic and phytogeographic peculiarities of stands of the association *Caricetum firmae* s. lat. in the South Tyrolian Dolomites. He found that because of the presence of a larger number of endemic species *(e.g., Gentiana terglouensis, Sesleria sphaerocephala, Pedicularis rosea, P. rostrato-capitata, Achillea clavenae, Valeriana saxatilis, Potentilla nitida, Soldanella minima, Phyteuma sieberi*), they are well distinguished from central Alpine stands of the association and in the basic inventories of Aichinger (1933: Tab. 26 in 27) he proposed a Southeast-Alpine vicariant *Firmeto-Primuletum wulfenianae* Br.-Bl. 1933. The association was suitably described and typified by Wraber (1970) as *Gentiano terglouensis-Caricetum firmae* T. Wraber 1970, with an inventory that he surveyed on Mt. Jalovec at an altitude of 2600 m. Poldini & Feoli (1976) confirmed by phytogeographical and numerical analysis the association *Caricetum firmae* s. lat. in the South- and Southeastern Calcareous Alps in the context of a special, new association (*Gentiano terglouensis-Caricetum firmae*) or distinct phytogeographical race, in which they also took into account a synoptic table of respective association from the Julian Alps (39 unpublished relevés surveyed by T. Wraber).

The area of distribution of the association embraces the entire south-eastern Alps. The western boundary of the distribution area accords with the boundary of the alliance *Caricion austroalpinae*, in the Insubrian region (between the lakes Lago di Como and Lago Maggiore). The most south-easterly stands thrive in the Kamnik-Savinja Alps. In Austria, impoverished stands of the association have also been observed on Dobrač (in Grabherr *et al.*, 1993). *Carex firma* stands extend to the Dinarides, all the way to Mt. Lička Plješivica (Horvat, 1930, 1952), and in the distribution area between Mts. Snežnik (SW Slovenia) and Trovrh (NW Croatia) they form a Dinaric vicariant *Edraiantho graminifolii-Caricetum firmae* Horvat (1930) 1934 (*Seslerion juncifoliae* Horvat 1930, *Seslerietalia juncifoliae* Horvat 1930), for which the presence of Illyrian and Dinaric or the absence of several Alpine species is characteristic.

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Appendix

Localities of relevés: Slovenia, Julian Alps, Krn mountains:

1. slope above the Zelena škrbina pass, on top of the gorge between Velika Montura and Velika Baba Mts. MTB: 9748/1, UTM: VM02; leg. & det.: B. Surina, 5.7.2002. **2**. just below the summit of Velika Montura. MTB: 9748/1, UTM: VM02; leg. & det.: D. Stešević & B. Surina, 29.7.2003. **3**. stony ridge above the Škedenj ridge. MTB: 9748/1, UTM: UM92; leg. & det.: I. Dakskobler & B. Surina, 8.8.2002. **4**. the summit of Mt. Mali Šmohor. MTB: 9748/1, UTM: UM92; leg. & det.: B. Surina, 9.7.2002. **5**. eastern slope of peak Palec. MTB: 9748/1, UTM: VM02; leg. & det.: I. Dakskobler & B. Surina, 8.8.2002. **6**. Polovnik ridge, between the peaks Krasji vrh and Veliki vrh. MTB: 9747/2, UTM: UM92; leg. & det.: I. Dakskobler & B. Surina, 18.7.2003. **7**. between Škofič and Rdeči rob Mts. MTB: 9748/1, UTM: UM92; leg. & det.: I. Dakskobler & B. Surina,

12.6.2002. **8**. north-eastern slope of Mt. Krnčica. MTB: 9747/2, UTM: UM92; leg. & det.: B. Surina, 23.7.2003. **9**. ridge of Mt. Škofič above Gorenja Lašca. MTB: 9748/1, UTM: UM92; leg. & det.: I. Dakskobler & B. Surina, 15.7.2003. **10**. north-eastern slope of Mt. Lopatnik. MTB: 9747/2, UTM: UM92; leg. & det.: B. Surina, 22.7.2003. **11**. north-western slope of Mt. Krnčica (the vegetation was overgrazed by sheep). MTB: 9747/2, UTM: UM92; leg. & det.: B. Surina, 23.7.2003. **12**. ridge between Krn and Srednji vrh Mts. MTB: 9747/2, UTM: UM92; leg. & det.: B. Surina, 22.8.2003. **13**. rocky ledge on south-western slope of Mt. Krnčica by »via ferrata« from Vratca pass to the summit of Mt. Krnčica (remnants from World War I.). MTB: 9747/2, UTM: UM92; leg. & det.: B. Surina, 23.7.2003. **14**. rocky grassland on north-western slope of Mt. Rdeči rob. MTB: 9748/1, UTM: UM92; leg. & det.: I. Dakskobler & B. Surina, 15.7.2003. **15**. Polovnik ridge, gorge in the ridge of peak Veliki vrh. MTB: 9747/1, UTM: UM82; leg. & det.: I. Dakskobler & B. Surina, 18.7.2003. **16-18**. Polovnik ridge, gorge in the ridge of peak Veliki vrh. MTB: 9747/1, UTM: UM82; leg. & det.: I. Dakskobler & B. Surina, 18.7.2003. **19**. Planina Duplje pasture, scree above the lake at Planina Duplje beneath the paths from Koča pri Krnskih jezerih mountain chalet to Lepoče. MTB: 9748/1, UTM: UM92; leg. & det.: B. Surina, 24.6.2002. **20-21**. Gorenja Lašca. MTB: 9748/1, UTM: UM92; leg. & det.: I. Dakskobler & B. Surina, 8.8.2002. **22**. Peak Mali Peski, northwest from the monument. MTB: 9748/1, UTM: UM92; leg. & det.: B. Surina, 30.8.2002. **23**. western slope of Mt. Vrh nad Peski, above Batogniška škrbina pass. MTB: 9748/1, UTM: UM92; leg. & det.: D. Stešević & B. Surina, 30.7.2003. **24**. Peak Škofič. MTB: 9748/1, UTM: UM92; leg. & det.: B. Surina, 30.8.2002. **25**. Gorenja Lašca, scree below the path from Mt. Veliki Peski to Lašca pasture. MTB: 9748/1, UTM: UM92; leg. & det.: I. Dakskobler & B. Surina. **26-27**. ridge between the peaks Mali Peski and Škofič. MTB: 9748/1, UTM: UM92; leg. & det.: B. Surina, 30.8.2002. **28**. Peak Škofič, pass between Lašca and Peski. MTB: 9748/1, UTM: UM92; leg. & det.: B. Surina, 30.8.2002.

ZDRUŽBA *GENTIANO TERGLOUENSIS-CARICETUM FIRMAE* T. WRABER 1970 V KRNSKEM POGORJU (JULIJSKE ALPE)

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POVZETEK

*Prispevek obravnava fitocenološke in okoljske razmere čvrstega šašja (*Caricetum firmae *s. lat.) v Krnskem pogorju (Julijske Alpe). Pri raziskavah, kjer smo uporabljali sigmatistično (srednjeevropsko) metodo (Braun-Blanquet, 1964), smo fitocenološke popise najprej razvrstili v diagnostične skupine in jih kasneje potrdili s pomočjo računalniškega programa SYN-TAX oziroma z metodo hierarhične klasifikacije (Podani, 1993). Za mero različnosti smo uporabljali komplement koeficienta "similarity ratio". Večinoma smo uporabljali metodo minimalnega porasta vsote kvadratov ostanka (Minimization of increase of error sum of squares - MISSQ), metodo kopičenja na osnovi najbolj oddaljenega soseda (Farthest neighbour-Complete linkage clustering) ter ordinacijsko metodo (Principal coordinates analysis - PCoA). Če se je izkazalo za potrebno in smiselno, smo preučevane sestoje členili na nižje enote. Pri primerjavi življenjskih oblik s pomočjo numerične analize smo po predhodno opravljeni linearni transformaciji ocen pokrovnosti za posamezne taksone (van der Maarel, 1979: r=1, +=2, 1=3, 2=5, 3=7, 4=8, 5=9) izračunali tudi indeks pokrovnosti (I_C, Lausi* et al.*, 1982) in delež pokrivanja vsakega taksona v okviru popisa oziroma celotne asociacije ($D_{\%}$). Skupine diagnostičnih vrst smo ob upoštevanju več avtorjev oblikovali po lastnih kriterijih. Floristično sestavo sestojev smo analizirali tudi po horoloških skupinah in Raunkiaerovih bioloških oblikah. Pri tem smo se ravnali po Atlasu flore Furlanije-Julijske krajine (Poldini, 1991), imena praprotnic in semenk pa navajamo po Registru flore Slovenije (Trpin & Vreš, 1995) ter Mali flori Slovenije (*Martinčič* et al.*, 1999).*

Sestoji s prevladujočo vrsto Carex firma *poraščajo vetrovom izpostavljena rastišča na vršnih predelih gora v subalpinskem in alpinskem pasu. Ponekod jih najdemo na izrazito hladnih rastiščih na manjši nadmorski višini. Po predhodnih primerjavah s podobnimi sestoji iz jugovzhodnih apneniških Alp smo jih uvrstili v asociacijo* Gentiano terglouensis-Caricetum firmae *T. Wraber 1970. Sestoje te asociacije, v primerjavi s sestoji centralno-alpske (*Caricetum firmae *Gams 1936), zaznamuje obstoj večjega števila endemitov in južno- oziroma jugovzhodnoalpskih vrst.*

Asociacijo smo na podlagi floristične sestave posameznih sestojev in numeričnih analiz tipološko dalje členili na subasociacije -dryadetosum octopetalae *Poldini & Feoli 1976,* -geranietosum argentei *subass. nova in* -potentilletosum nitidae *subass. nova. Sestoji subasociacije* -dryadetosum octopetalae *so v sindinamični povezavi s sestoji asociacije* Dryadetum octopetalae *Rübel 1911 oziroma s stadijem* Dryas octopetala*, ki je pionirski tip vegetacije predvsem na deloma ustaljenih meliščih. Za razlikovalnice subasociacije* -dryadetosum *smo izbrali vrste* Dryas octopetala, Athamantha cretensis *in* Leontodon hispidus *s. lat.*

Sestoji subasociacije -potentilletosum nitidae *kažejo floristično in sintaksonomsko podobnost s sestoji asociacije* Potentilletum nitidae *Wikus 1959 iz razreda* Asplenietea trichomanis *(Br.-Bl. in Meier & Br.-Bl. 1934) Oberdorfer 1977; poraščajo vlažna in hladna, proti severu izpostavljena rastišča. Razlikovalne vrste za subasociacijo* -potentilletosum nitidae *so vrste* Potentilla nitida, Oxytropis jacquinii, Primula auricula, Campanula zoysii, Paederota lutea *in* Petrocallis pyrenaica*. Sindinamično povezanost in posledično floristično sorodnost sestojev asociacije* Gentiano terglouensis-Caricetum firmae *s sestoji vegetacije snežnih tal iz zveze* Soldanello alpinae-Salicion retusae *Englisch 1999 (predvsem s sestoji asociacij* Homogyno discoloris-Salicetum retusae *Aichinger 1933 in* Salici retusae-Geranietum argentei *Surina 2004) pa kažejo sestoji, ki smo jih uvrstili v subasociacijo* -geranietosum argentei*. Za razlikovalnice slednje smo določili vrste* Geranium argenteum, Polygonum viviparum, Festuca nitida, Drepanocladus uncinatus *in* Oncophorus virens*. Uveljavljajo se na rastiščih z dolgotrajno snežno odejo.*

Sestoji asociacije Gentiano terglouensis-Caricetum firmae *so razširjeni v celotnih jugovzhodnih Alpah. Areal asociacije sega na zahodu do Insubrijske regije oziroma do gora med jezeroma Lago di Como in Lago Maggiore ter na vzhodu do Kamniško-Savinjskih Alp. V slovenskih Alpah (skupaj s Karnijskimi pripadajo Jugovzhodnim Apneniškim Alpam) uspevajo v Julijskih Alpah, Karavankah in v Kamniško-Savinjskih Alpah. V Avstriji so floristično obubožane sestoje te asociacije opazili na Dobraču. Sestoje čvrstega šašja iz Liburnijskega krasa med Snežnikom in Ličko Plješivico uvrščamo v dinarsko vikarianto* Edraiantho graminifolii-Caricetum firmae *Horvat (1930) 1934 iz zveze* Seslerion juncifoliae *Horvat 1930 in reda* Seslerietalia juncifoliae *Horvat 1930. Za sestoje te asociacije je že značilna prisotnost ilirskih (dinarskih) vrst na eni ter odsotnost nekaterih alpskih vrst na drugi strani.*

Ključne besede: fitocenologija, fitogeografija, endemične vrste, *Elyno-Seslerietea*, *Caricion firmae*, *Caricetum firmae*, Jugovzhodne Apneniške Alpe

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Tab. 1: Phytosociological table: analytical table of the association *Gentiano terglouensis-Caricetum firmae* ***T. Wraber 1970 in the Krn Mts. (the Julian Alps).***

Tab. 1: Fitocenološka tabela: analizna tabela asociacije *Gentiano terglouensis-Caricetum firmae* ***T. Wraber 1970 v Krnskem pogorju (Julijske Alpe).***

Relevé number		**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8***	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18***	**19**	**20**	**21**	**22**	**23**	**24**	**25**	**26**	**27**	**28**					
Altitude (m a.s.l.)		1900	1945	1740	1944	1580	1700	1884	2120	1920	1965	2040	2050	2040	1900	1700	1680	1700	1680	1330	1605	1705	2020	2110	1955	1755	1965	1975	1945					
Exposition		N	N	NW		N	N	W	SW	NW	SW	E	NE	W	NE	N	NE	N	E	N	NE		NW	N	N	NE	N	N	N					
Inclination (^{0})		10	15	30	0	45	50	60	5	15	15	45	5	10	25	20	30	20	70	30	5	0	10	20	20	40	10	20	10					
Coverness (%) Herb layer		90	90	100	80	70	80	90	95	95	70	95	100	90	40	70	70	80	70	80	90	75	95	95	90	60	90	90	100					
Moss layer	D	1	1			10	10	20	20	10	20	1	5	20						5	5	5	1	1	1	1	1	10						
Relevé area (m^2)		6	3	2	6	5	4	4	4	25	4	8	2	4	12	4	4	4	4	6	4	4	25	2	6	12	4	4	1					
Number of species		27	27	20	26	42	43	38	29	58	25	37	34	22	28	21	18	21	22	30	40	28	28	12	15	19	20	18	13	**fr**	**%**		**I_c**	**$D_{\%}$**
Characteristic species of the association																																		
Carex firma	He	4	4	4	4	4	4	4	4	4	4	5	5	5	1	4	4	4	4	4	3	3	4	4	5	3	2	3	2	28	100	**V**	85	10.8
Helianthemum alpestre	Ha	+	+	.	2	+	1	1	+	1	.	+	.	+	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	11	39	**II**	12	1.5
Crepis kerneri	He	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	+	+	+	.	.	+	+	+	+	8	29	**II**	6	0.8
Saussurea pygmaea	He	.	.	.	.	.	.	.	1	.	.	+	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	3	11	**I**	3	0.4
Chamorchis alpina	Ge	.	.	.	.	.	.	.	.	.	.	+	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2	7	**I**	2	0.2
Saxifraga caesia	Ha	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	4	**I**	1	0.1
Differential species of the association (versus Caricetum firmae Lüdi 1911)																																		
Phyteuma sieberi	He	1	+	+	+	+	.	+	1	1	+	+	+	1	+	.	+	+	.	.	.	1	+	+	+	+	+	1	+	23	82	**V**	21	2.6
Pedicularis rostrato-capitata	He	+	+	+	+	+	1	+	+	+	+	+	+	+	+	+	.	+	+	.	.	.	.	.	.	.	.	+	.	.	18	64	**IV**	15	1.9
Saxifraga squarrosa	Ha	+	+	.	+	1	+	+	.	+	1	+	+	+	.	+	.	+	+	.	.	.	.	+	+	.	.	+	.	17	61	**IV**	14	1.8
Sesleria sphaerocephala	He	+	.	2	+	1	.	.	+	.	+	.	+	1	.	.	.	.	.	.	.	.	+	+	.	.	.	1	+	12	43	**III**	12	1.5
Achillea clavenae	He	.	.	.	+	+	+	+	.	1	.	.	.	.	+	.	.	.	.	.	+	+	+	+	.	.	.	.	+	11	39	**II**	9	1.2
Gentiana terglouensis	He	+	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	+	.	.	+	+	+	.	.	.	.	6	21	**II**	5	0.6
Differential species of subassociations																																		
Polygonum viviparum	Ge	.	+	.	+	.	1	1	2	1	1	.	1	1	+	1	.	.	.	1	+	1	+	+	.	+	+	.	.	18	64	**IV**	19	2.4
Festuca nitida	He	.	.	.	.	.	+	.	2	1	+	.	1	.	.	+	.	.	.	.	+	+	+	.	.	.	.	.	.	9	32	**II**	9	1.2
Drepanocladus uncinatus	D	.	.	.	.	.	.	+	2	2	3	.	1	2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	6	21	**II**	.	
Geranium argenteum	He	.	.	.	.	.	.	2	+	+	.	+	+	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	6	21	**II**	6	0.8
Oncophorus virens	D	.	.	.	.	.	.	+	+	.	1	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	4	14	**I**	.	
Potentilla nitida	Ha	+	.	.	.	.	.	.	.	.	.	.	.	1	.	2	3	2	3	.	.	.	.	1	.	.	.	+	+	9	32	**II**	14	1.8
Oxytropis jacquinii	He	.	.	.	1	.	.	+	+	.	.	.	.	.	1	+	+	+	+	.	.	.	.	.	.	.	.	.	.	8	22	**I**	7	0.9
Primula auricula	He	.	.	.	.	1	+	.	.	.	.	+	.	.	.	+	+	+	+	.	.	.	.	.	.	.	.	.	.	7	25	**II**	6	0.8
Campanula zoysii	He	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	+	+	+	.	.	.	.	.	.	.	.	.	.	4	14	**I**	3	0.4
Paederota lutea	He	.	.	.	.	.	+	+	.	.	.	.	.	.	.	.	+	.	+	.	.	.	.	.	.	.	.	.	.	4	14	**I**	3	0.4
Petrocallis pyrenaica	Ha	.	.	.	.	.	.	.	.	+	.	.	.	.	.	+	.	+	+	.	.	.	.	.	.	.	.	.	.	4	14	**I**	3	0.4
Dryas octopetala	Ha	1	2	1	.	+	.	.	1	3	+	2	2	2	+	.	.	.	.	1	4	4	2	2	3	4	4	3	5	21	75	**IV**	44	5.6
Athamanta cretensis	He	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	+	1	+	.	.	.	+	+	+	+	8	29	**II**	7	0.9
Leontodon hispidus s. lat.	He	.	.	.	.	.	.	.	.	+	.	.	+	.	.	.	.	.	.	.	1	1	.	.	.	.	.	+	+	6	21	**II**	6	0.7
Caricion austroalpinae																																		
Koeleria eriostachya	He	.	+	.	+	.	+	.	.	+	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	5	18	**I**	4	0.5
Linum julicum	He	.	.	.	.	.	.	.	.	.	.	+	+	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	3	11	**I**	2	0.3
Laserpitium peucedanoides	He	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	2	7	**I**	2	0.2
Senecio abrotanifolius	Ha	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	1	4	**I**	1	0.2
Trifolium noricum	He	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	4	**I**	1	0.1

Caricion firmae, Seslerietalia caeruleae & Elyno-Seslerietea

Aster bellidiastrum	He	+	+	+	+	+	+	+	.	1	+	+	1	.	.	+	+	+	.	1	.	.	1	.	1	+	1	.	+	20	71	IV	18	2.3
Sesleria albicans	He	+	+	.	+	1	1	+	1	+	.	1	1	.	+	1	1	1	2	.	+	.	+	+	.	.	.	.	.	18	64	IV	19	2.5
Gentiana clusii	He	+	+	+	2	+	+	+	.	+	.	1	1	.	.	.	.	.	.	.	+	.	.	.	+	.	+	.	.	13	46	III	12	1.6
Leontopodium alpinum	He	+	.	.	+	+	.	+	+	+	.	+	.	.	.	1	+	.	+	.	.	.	.	.	.	.	.	.	.	10	36	II	8	1.1
Anthyllis vulneraria / alpe stris	He	+	.	.	+	+	.	.	.	+	.	+	1	.	+	.	.	.	.	+	+	.	.	.	.	.	+	.	.	10	36	II	8	1.1
Ranunculus hybridus	He	.	.	.	.	1	1	+	.	.	.	1	.	.	+	+	1	+	+	.	.	.	.	.	.	.	.	.	.	9	32	II	9	1.1
Silene acaulis	Ha	.	.	.	.	.	.	+	+	1	.	+	+	+	2	.	.	.	.	.	+	1	.	.	.	.	.	.	.	9	32	II	9	1.2
Pinguicula alpina	He	+	+	+	.	+	1	.	.	+	.	.	.	.	.	.	.	+	.	+	.	.	.	.	1	.	.	.	.	9	32	II	8	1.0
Salix alpina	Fa	.	+	.	.	.	.	+	+	1	.	+	.	.	.	.	.	.	.	+	+	1	.	.	.	.	.	.	.	8	29	II	7	0.9
Thymus alpigenus	Ha	.	.	.	+	.	.	.	.	1	+	1	+	.	+	.	.	.	.	2	+	.	.	.	.	.	.	.	.	8	29	II	8	1.1
Homogyne discolor	He	1	1	.	.	.	.	.	.	1	.	+	+	.	.	.	.	.	.	.	+	.	1	.	.	.	.	.	.	7	25	II	7	0.9
Carex sempervirens	He	+	.	.	+	+	.	.	.	.	.	.	.	.	.	.	.	.	.	+	+	.	+	.	.	.	+	.	.	7	25	II	6	0.7
Hieracium villosum	He	.	.	+	.	+	+	.	.	+	.	+	.	.	+	.	+	.	.	.	.	.	.	.	.	.	.	.	.	7	25	II	6	0.7
Hedysarum hedysaroides	He	.	.	.	.	+	1	+	2	.	+	+	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	7	25	II	7	0.9
Poa alpina	He	.	+	.	.	.	.	.	.	+	.	1	.	+	.	.	.	.	.	.	+	+	+	.	.	.	.	.	.	7	25	II	6	0.8
Androsace villosa	Ha	1	1	.	1	.	.	+	.	+	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	6	21	II	6	0.8
Galium anisophyllum	He	.	.	.	+	.	+	.	+	1	.	.	.	.	.	.	.	.	.	1	.	.	+	.	.	.	.	.	.	6	21	II	6	0.7
Bartsia alpina	He	.	.	.	.	+	+	+	.	.	.	+	.	.	.	+	.	.	.	.	.	.	.	.	.	.	1	.	.	6	21	II	5	0.7
Euphrasia salisburgensis	Te	.	.	+	.	.	.	.	.	.	.	+	+	.	.	.	.	.	.	.	.	.	.	.	+	.	+	+	.	6	21	II	5	0.6
Erigeron glabratus	He	.	.	.	.	.	+	+	+	+	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	5	18	I	4	0.5
Aster alpinus	He	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	+	.	.	.	+	.	.	.	.	+	+	5	18	I	4	0.5
Astrantia bavarica	He	.	.	.	.	1	+	.	.	+	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	4	14	I	4	0.5
Carex mucronata	He	.	.	.	.	.	+	.	.	.	.	.	.	.	.	+	.	.	+	.	.	+	.	.	.	.	.	.	.	4	14	I	3	0.4
Heliosperma alpestre	Ha	.	.	.	.	.	1	.	.	+	.	.	.	.	.	.	.	.	.	1	.	+	.	.	.	.	.	.	.	4	14	I	4	0.5
Biscutella laevigata	He	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	+	1	.	.	.	.	.	.	.	3	11	I	3	0.4
Salix serpyllifolia	Fa	.	.	.	.	.	+	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	3	11	I	2	0.3
Potentilla crantzii	He	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	+	.	.	.	.	.	.	.	.	3	11	I	2	0.3
Pedicularis verticillata	He	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	+	.	+	.	.	.	.	3	11	I	2	0.3
Gentianella anisodonta	Te	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	+	.	+	.	.	.	.	.	.	3	11	I	2	0.3
Euphrasia picta	Te	.	.	.	.	.	.	.	.	.	+	.	+	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	3	11	I	2	0.3
Ranunculus carinthiacus	He	.	.	.	.	.	.	+	.	.	.	.	+	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	3	11	I	2	0.3
Gentiana verna	He	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	2	7	I	2	0.2
Carlina acaulis / simplex	He	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	+	.	.	.	.	.	.	.	2	7	I	2	0.2
Pulsatilla alpina	He	.	.	.	.	+	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2	7	I	2	0.2
Thesium alpinum	He	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	2	7	I	2	0.2
Anemone narcissiflora	Ge	.	.	.	.	+	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2	7	I	2	0.2
Campanula scheuchzeri	He	.	.	.	.	.	+	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2	7	I	2	0.2
Daphne striata	Fa	.	.	+	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2	7	I	2	0.2
Coeloglossum viride	Ge	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	4	I	1	0.2
Gentiana nivalis	Te	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	4	I	1	0.1
Betonica alopecuros	He	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	1	4	I	1	0.1
Helianthemum grandifl orum	Ha	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	4	I	1	0.1
Hieracium bifidum	He	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	4	I	1	0.1
Myosotis alpestris	He	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	4	I	1	0.1
Polygala alpestris	He	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	4	I	1	0.1
Rhinanthus aristatus / aristatus	Te	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	1	4	I	1	0.1
Alchemilla velebitica	He	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	4	I	1	0.1
Anthoxanthum nipponicum	He	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	4	I	1	0.1
Arabis vochinensis	Ha	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	1	4	I	1	0.1
Cerastium subtriflorum	He	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	4	I	1	0.1
Euphrasia pulchella	Te	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	4	I	1	0.1
Gentiana pumila	He	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	4	I	1	0.1
Gentiana utriculosa	Te	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	4	I	1	0.1
Lotus corniculatus	He	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	1	4	I	1	0.1

TR **Thlaspietea rotundifolii s. lat.**																																			
Campanula cochleariifolia	He	.	.	.	.	.	.	.	.	.	1	.	.	+	+	+	+	1	+	.	+	1	.	.	.	+	+	+	.	12	43	III	11	1.4
Ranunculus traunfellneri	He	+	+	.	.	+	.	.	.	.	+	.	+	.	.	.	.	.	.	1	+	+	+	+	.	+	.	.	+	12	43	III	10	1.3
Soldanella minima	He	+	+	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	1	+	.	1	.	.	+	1	.	.	8	29	II	8	1.0
Salix retusa	Fa	.	.	.	.	.	+	+	+	+	+	.	.	.	.	.	.	.	.	.	.	.	1	4	.	+	.	.	.	8	29	II	8	1.1
Juncus monanthos	He	.	.	.	.	.	.	1	.	+	+	.	.	.	.	.	+	+	.	+	.	+	.	.	.	.	.	.	.	7	25	II	6	0.8
Saxifraga aizoides	Ha	.	.	.	.	+	+	+	.	.	+	.	+	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	6	21	II	5	0.7
Cerastium austroalpinum	Ha	.	.	.	.	.	.	.	.	+	+	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	4	14	I	3	0.4
Gypsophila repens	Ha	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	+	.	+	.	.	.	.	.	.	.	.	.	.	3	11	I	2	0.3
Thlaspi kerneri	Ha	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	+	.	.	.	3	11	I	2	0.3
Soldanella alpina	He	.	.	.	.	.	1	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2	7	I	2	0.3
Achillea atrata	He	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	+	.	.	.	.	.	.	.	2	7	I	2	0.2
Armeria alpina	He	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	2	7	I	2	0.2
Festuca laxa	He	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	+	.	.	.	2	7	I	2	0.2
Minuartia austriaca	Ha	.	.	.	.	.	.	.	+	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2	7	I	2	0.2
Silene vulgaris / glareosa	Ha	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	+	.	.	.	.	.	.	.	2	7	I	2	0.2
Alyssum ovirense	Ha	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	1	4	I	1	0.1
Moehringia ciliata	He	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	1	4	I	1	0.1
Poa minor	He	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	1	4	I	1	0.1
Rumex scutatus	He	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	1	4	I	1	0.1
AT **Asplenietea trichomanis**																																			
Valeriana saxatilis	He	1	1	1	.	1	1	.	.	+	.	+	.	+	.	1	1	2	+	.	+	.	.	.	+	+	+	.	.	16	57	III	17	2.1
Saxifraga crustata	Ha	.	+	.	.	+	1	+	+	.	+	+	.	+	1	+	+	+	+	.	.	.	.	.	+	.	.	.	.	14	50	III	12	1.5
Viola biflora	He	+	1	+	.	+	.	+	+	.	+	.	.	.	.	+	+	.	+	.	+	.	+	.	.	.	.	.	.	12	43	III	10	1.3
Minuartia sedoides	Ha	.	.	.	.	.	.	+	+	+	2	.	+	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	6	21	II	6	0.8
Potentilla clusiana	He	.	.	+	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	1	4	14	I	4	0.5
Saxifraga paniculata	Ha	.	.	.	.	.	.	+	.	.	.	.	+	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	3	11	I	2	0.3
Saxifraga burseriana	Ha	.	.	.	.	.	.	+	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2	7	I	2	0.2
Asplenium viride	He	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	2	7	I	2	0.2
Bupleurum petraeum	He	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	1	4	I	1	0.2
Asperula aristata	He	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	4	I	1	0.1
Astragalus australis	He	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	4	I	1	0.1
Carex atrata	He	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	4	I	1	0.1
Carex capillaris	He	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	4	I	1	0.1
Minuartia rupestris	Ha	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	4	I	1	0.1
Saxifraga tenella	Ha	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	4	I	1	0.1
Arabis pumila / stellulata	Ha	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	1	4	I	1	0.1
Valeriana elongata	He	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	1	4	I	1	0.1
EP **Erico-Pinetea**																																			
Rhodothamnus chama ecistus	Fa	+	+	1	+	2	3	.	.	+	1	2	2	2	.	2	.	2	+	.	.	+	.	.	1	+	2	1	.	19	68	IV	27	3.5
Rhododendron hirsutum	Fa	.	+	+	.	+	+	.	.	+	+	2	+	+	.	.	.	.	.	.	+	.	.	.	+	+	1	+	.	14	50	III	13	1.6
Arctostaphyllos alpina	Fa	.	+	+	+	1	1	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	2	+	.	8	29	II	8	1.1
Calamagrostis varia	He	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	1	4	I	1	0.1
Larix decidua	Fa	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	4	I	1	0.1
VP **Vaccinio-Piceetea**																																			
Selaginella selaginoides	Ha	1	1	+	.	1	+	.	.	+	.	+	+	+	.	.	.	+	.	+	1	1	+	.	.	.	.	.	.	14	50	III	13	1.7
Picea abies	Fa	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	2	7	I	2	0.2
Pinus mugo	Fa	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	1	4	I	1	0.1
Vaccinium vitis-idaea	Ha	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	4	I	1	0.1
Huperzia selago	Ha	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	4	I	1	0.1
Other species																																			
Salix waldsteiniana	Fa	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	+	.	.	.	3	11	I	2	0.3
Salix appendiculata	Fa	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	4	I	1	0.1
Tofieldia calyculata	He	1	+	.	+	+	1	.	.	+	.	.	.	.	.	.	.	+	.	2	1	+	+	.	.	.	+	.	.	12	43	III	12	1.5
Festuca sp.	He	.	+	.	.	.	.	.	+	+	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	4	14	I	3	0.4
Parnassia palustris	He	.	.	.	.	.	+	+	.	.	.	+	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	4	14	I	3	0.4

Homogyne alpina	He	.	.	.	.	1	1	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	3	11	I	3	0.4
Lloydia serotina	Ge	.	.	.	.	.	.	1	+	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	3	11	I	3	0.4
Alchemilla flabellata	He	.	.	.	.	.	+	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2	7	I	2	0.2
Carex ornithopoda	He	.	.	.	.	+	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2	7	I	2	0.2
Daphne mezereum	Fa	.	.	+	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2	7	I	2	0.2
Globularia cordifolia	Ha	+	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	2	7	I	2	0.2
Linum catharticum	Te	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	+	.	.	.	.	.	.	.	2	7	I	2	0.2
Alchemilla cinerea	He	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	4	I	1	0.1
Festuca nigrescens	He	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	4	I	1	0.1
Gentianella ciliata	He	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	1	4	I	1	0.1
Gnaphalium supinum	He	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	1	4	I	1	0.1
Hieracium sylvaticum	He	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	4	I	1	0.1
Laserpitium siler	He	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	4	I	1	0.1
Luzula multiflora	He	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	4	I	1	0.1
Poa sp.	He	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	4	I	1	0.1
Pseudorchis albida	Ge	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	1	4	I	1	0.1
Trifolium pallescens	He	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	4	I	1	0.1

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POJAVLJANJE JADRANSKE SMRDLJIVE KUKAVICE (*HIMANTOGLOSSUM ADRIATICUM* H. BAUMANN) V HALOZAH (SV SLOVENIJA)

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IZVLEČEK

Obravnavano je pojavljanje vrste Himantoglossum adriaticum *H. Baumann v Sloveniji. Razlikujemo med submediteranskim in preostalim delom njenega areala v Sloveniji. Medtem ko je vrsta v submediteranskem delu pogosta, pa je v preostalem delu Slovenije redka in upada. Menimo, da so njena razpršena in izolirana nahajališča, nepotrjena že več desetletij, izginila zaradi fragmentacije habitatov in njenih posledic. Na območju Vinorodnih Haloz (SV Slovenija) je bilo v zadnjih 6 letih odkritih in spremljanih 11 nahajališč s približno 450 cvetočimi primerki. Menimo, da gre v Vinorodnih Halozah za viabilno populacijo, kar povezujemo s pojavljanjem v gostem omrežju majhnih površin suhih travnikov iz zveze* Mesobromion *kot tudi z ugodno toplo klimo in ustreznimi talnimi razmerami. Govor je tudi o možnem izvoru te populacije prek "gibljivih koridorjev" s transhumanco.*

Ključne besede: *Himantoglossum adriaticum*, Vinorodne Haloze, SV Slovenija, areal, *Mesobromion*

PRESENZA DEL BARBONE ADRIATICO (*HIMANTOGLOSSUM ADRIATICUM* H. BAUMANN) NELLA ZONA DI HALOZE (SLOVENIA NORD-ORIENTALE)

SINTESI

Viene esaminata la presenza della specie Himantoglossum adriaticum *H. Baumann in Slovenia, con una distinzione tra la parte submediterranea e quella restante del suo areale. Mentre nella zona submediterranea essa è frequente, nel resto della Slovenia è rara e in diminuzione. Riteniamo che le stazioni di crescita, disperse e isolate – e già da decenni non più confermate – si siano estinte in seguito alla frammentazione degli habitat. Negli ultimi sei anni, nella zona vinifera di Haloze (Slovenia nord-orientale) sono state scoperte e monitorate undici stazioni di crescita, con circa 450 esemplari in fioritura. In questo caso, riteniamo si tratti di una popolazione viabile; è una considerazione che ci viene dettata dalla sua presenza in un fitta rete di piccoli prati semisecchi dell'alleanza* Mesobromion *(formazione a pratelli), come pure dal favorevole clima caldo e dalle idonee condizioni del terreno. E'indicata pure la possibile origine di tale popolazione, attraverso i "corridoi mobili" della transumanza.*

Parole chiave: *Himantoglossum adriaticum*, zona vinifera di Haloze, Slovenia nord – orientale, areale, *Mesobromion*

UVOD

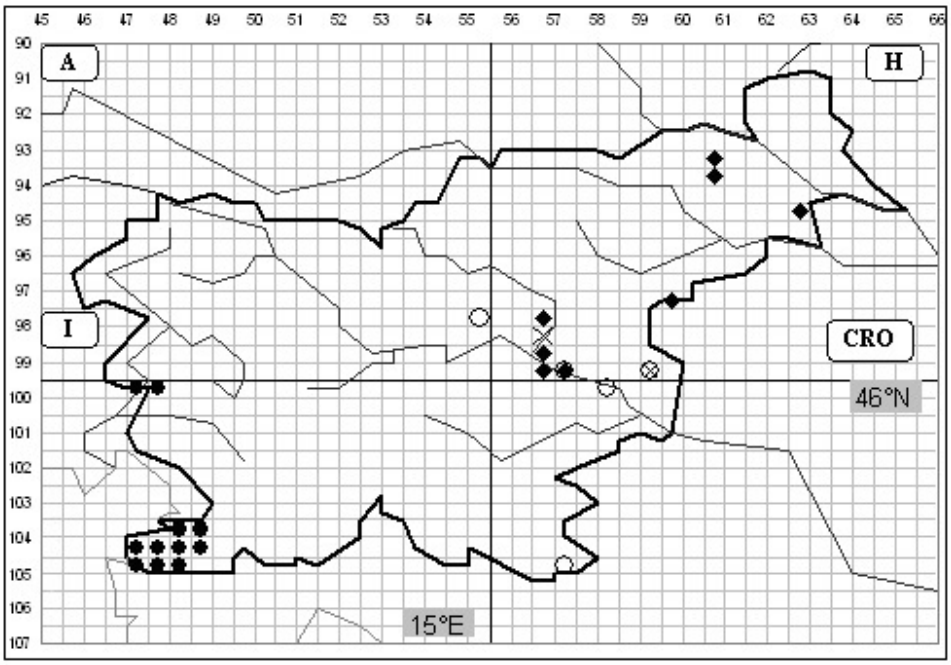
Jadranska smrdljiva kukavica (*Himantoglossum adriaticum* H. Baumann) je bila opisana šele leta 1978, in sicer je Baumann (1978) razlikoval populacije vrste *Himantoglossum hircinum*, ki so pod submediteranskim vplivom razširjene južno od Alp v Italiji, zahodnem Balkanu in delu Srednje Evrope (Slovenija, Hrvaška, Madžarska, Avstrija, Slovaška) od populacij v Evropi širše razširjene vrste *H. hircinum*. Delforge (1995) sicer poroča o možni kontaktni coni vrste *H. hircinum* z vrsto *Himantoglossum caprinum* prav v tem delu Evrope (Avstrija, Madžarska, Jugoslavija), hibridi pa naj bi pripadali na novo opisani vrsti *H. adriaticum.* O anevploidiji poročajo Demerico *et al.* (1993). Vsi primerki iz herbarija LJU, določeni pred letom 1978 kot *H. hircinum*, so bili s strani Baumanna revidirani v vrsto *H. adriaticum*. Isto pripadnost za primerke iz Slovenije lahko pripišemo tudi starim literaturnim podatkom. Vrsta je v Istri in ponekod v toplejših predelih na Krasu razmeroma pogosta (Kaligarič, 1991). V "celinski" Sloveniji pa je izjemno redka, še posebej pa nazaduje v zadnjih desetletjih. Ko smo leta 1998 našli prve primerke te termofilne submediteranske vrste orhideje v Halozah (Štumberger *et al.*, 1999), smo se odločili, da temeljito raziščemo razširjenost njene "celinske" populacije in poskušamo ugotoviti njeno gostoto, stabilnost, ekološke potrebe in ogroženost.

Jadranska smrdljiva kukavica je do 80 cm visoka trajnica s celimi koreninskimi gomolji. Steblo ima številne liste, zgornji so suličasti, spodnji pa jajčasti ali podolgasti. Na bazi je pokrito z rjavkastimi laski. Cvetovi z ostrogami so v 15 do 50 cm dolgem socvetju. Brakteje so krajše od cvetov. Medena ustna je obrnjena navzdol, podaljšana, trakasta in trokrpa. Njene krpe so ozko-črtalaste, srednja krpa je cca. 2 mm široka, neprimerno daljša od stranskih krp (dolga 3–7 cm) ter spiralasto zavita. Vsi cvetni listi razen medene ustne tvorijo čelado in so po notranji strani rdeče progasti, zunaj belkasti. Vonj je rahel in neprijeten. Kromosomsko število (2n) je 36 (Demerico *et al.,* 1993).

MATERIAL IN METODE

Opis območja Vinorodnih Haloz

Haloze so pokrajina nizkih terciarnih goric južno od Slovenskih goric, od katerih jih loči na tem mestu ne preveč široko Dravsko polje. Delimo jih na Vinorodne Haloze na vzhodu in Gozdnate Haloze na zahodu. Meja med Vinorodnimi in Gozdnatimi Halozami poteka po dolini potoka Peklača. Vinorodne Haloze tako obsegajo podolžni del Haloz od Belskega vrha na vzhodu



Sl. 1: Razširjenost smrdljive kukavice *(Himantoglossum adriaticum)* ***v Sloveniji po kvadrantih srednjeevropskega kartiranja flore. Legenda: ● submediteran; ○ pred letom 1950; ◆ Hayek (1956; temelji na starih podatkih, večinoma iz 19. stoletja in z začetka 20. stoletja); ⊗ T. Wraber (1955, 1969).***

Fig. 1: Distribution of the Adriatic Lizard Orchid *(Himantoglossum adriaticum)* ***in Slovenia per squares delineated for the mapping of Central European flora. Legend: ● sub-Mediterranean; ○ prior to 1950; ◆ Hayek (1956; based on old data, mostly from the 19th and early 20th centuries); ⊗ T. Wraber (1955, 1969).***

prek Cirkulan, Dravinjskega Vrha, Janškega Vrha do Makol (Perko & Orožen Adamič, 1998). Po geološki sestavi so izključno iz terciarnih kamenin v večini miocenske starosti, ki so iz mehkega laporja in peščenjaka. Ponekod je v majhni meri zastopan tudi litotamnijski apnenec. Na teh lapornatih terciarnih gričevjih so se razvile karbonatne rendzine (pararendzine) in evtrična rjava tla (Perko & Orožen Adamič, 1998).

Zaradi odprtosti proti vzhodu imajo Haloze značilno subpanonsko podnebje vzhodne Slovenije. Povprečna januarska temperatura za obdobje 1981–90 je bila 0,3°C in povprečna julijska temperatura za isto obdobje 19,2 °C. Povprečna letna temperatura je bila 10°C (Mekinda, 1995).V obdobju med letoma 1971 in 1980 je bila letna količina padavin povprečno 1100 mm (Zupančič, 1995).

Po delitvi M. Wraberja (1969) spadajo Haloze v subpanonsko fitogeografsko območje. Zupančič *et al.* (1987) pa uvrščajo to območje v haloški distrikt predpanonskega subsektorja jugovzhodnega sektorja ilirske province in evrosibirsko-severnoameriške regije.

Slabo polovico površja Haloz pokrivajo gozdovi. Na terciarnih kamninah je najbolj razširjen kisloljubi bukov gozd asociacije *Castaneo-Fagetum sylvaticae* (Marinček & Zupančič 1979) Marinček & Zupančič 1995. Po dolinah najdemo na sušnih, zakisanih rastiščih združbo *Vaccinio myrtilli-Carpinetum betuli* (Wraber 1969) Marinček 1994, na občasno poplavljenih rastiščih pa združbo *Fraxino pannonici-Carpinetum* Soó & Borhidi in Soó 1962. V jarkih in manjših globelih je razširjena bukova združba *Vicio oroboidi-Fagetum* (Horvat 1938) Pocs & Borhidi in Borhidi 1960, v kateri se pojavlja ilirsko-panonska vrsta *Festuca drymeia*. Negozdne površine sestavljajo travniki, pašniki, sadovnjaki in pa seveda vinogradi, ki pokrivajo kar desetino površin Vinorodnih Haloz. V nižinah in na položnejših pobočjih v bližini naselij prevladujejo intenzivno gojeni travniki reda *Arrhenatheretalia* R. Tx. 1931. Na bolj strmih, predvsem južnih pobočjih pa še vedno najdemo optimalne sestoje ekstenzivnih suhih in polsuhih travišč reda *Brometalia erecti* Koch 1926.

Popisovanje

V času cvetenja smrdljive kukavice (maj-julij 1998 – 2004) smo na terenu iskali primerna rastišča in šteli cvetoče primerke. Ko smo našli smrdljivo kukavico, smo omejili travnik, na katerem uspeva, ga označili na topografski karti in prešteli primerke. Nekatera rastišča smo obiskovali več let zaporedoma, nekatera pa le enkrat – kot nam je dopuščal čas. Za število primerkov/nahajališče smo upoštevali največje najdeno število.

Nomenklatura

Nomenklatura taksonov sledi Adler *et al.* (1994), sintaksonov pa Zupančič *et al.* (1987) in Škornik (2000).

REZULTATI IN DISKUSIJA

Dosedanji podatki o razširjenosti v Sloveniji

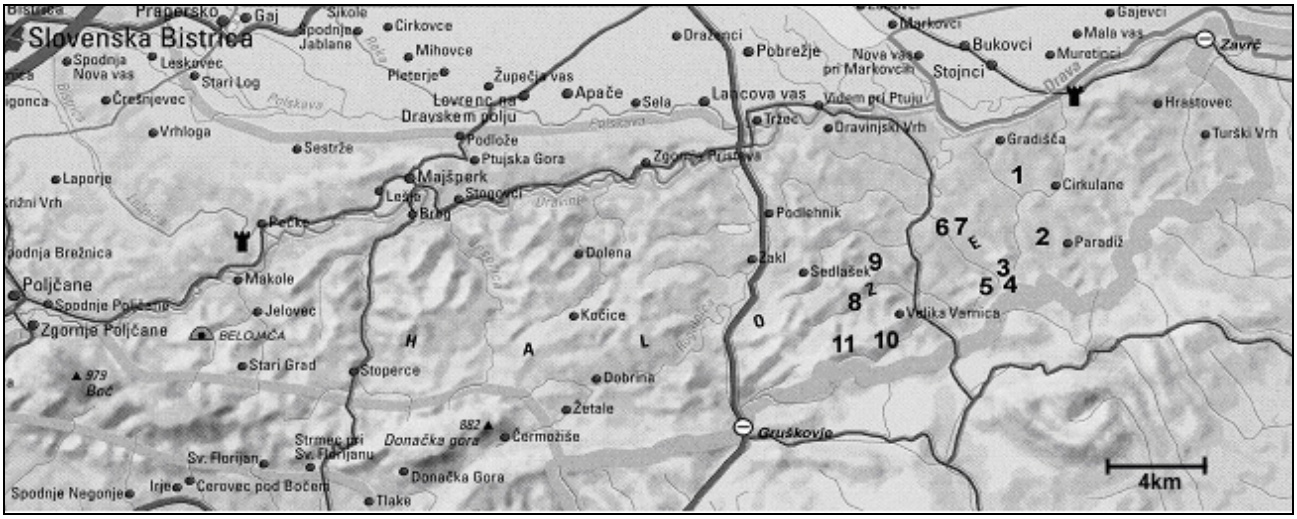
Podatke o razširjenosti vrste *H. adriaticum* lahko ločimo na dva dela areala, ki ga ta vrsta zavzema v Sloveniji: submediteranski del (Istra, Kras), kjer ni redka, in preostali del Slovenije. V submediteranskem delu je bila opažena tako rekoč v vseh kvadrantih (srednjeevropskega kartiranja flore) v Istri in ponekod na Krasu. Osnova za karto razširjenosti (Sl. 1), izdelano s pomočjo programskega paketa Kararas 3.0 (Jogan, 2001a), so podatki iz LJU, terenskih zapiskov M. Kaligariča in Gradiva za atlas flore Slovenije (Jogan, 2001b). Zaradi raztresenosti nahajališč je zanimivejša razširjenost zunaj submediterana. Po virih LJU je bila ta vrsta najdena le nekajkrat, in sicer v Zasavju, na Dolenjskem, v Beli krajini ter na Štajerskem. Vsi podatki, razen za Pišece nad Brežicami na Bizeljskem (LJU: T. Wraber, 1955) in Rimske Toplice (T. Wraber, 1969) so stari več kot 60 let in so le historične narave. To lahko trdimo ne le za herbarijske podatke (LJU), kjer najdemo pole od Justina, Paulina, Zalokarja, Schaeftleina, Dolšaka in Plemla, marveč tudi za Hayekove (1956) podatke: vsa nahajališča, ki jih navaja, so povzeta po starejših virih (npr. Glowacki, Verbniak, Alexander, Derganc, itd.). Hayekovega nahajališča "Ptuj" nismo uvrstili v karto razširjenosti zaradi nenatančne navedbe.

Popis primerkov na terenu

V letih 1998 do 2004 smo s podrobnim ciljnim pregledovanjem terena ugotovili večji del nahajališč te vrste v Vinorodnih Halozah. Ugotovljeno je bilo 11 nahajališč z okrog 450 primerki. Najmanjše število ugotovljenih primerkov je bilo 4, največje pa 200 (Velika Varnica 1). Nahajališča so prikazana na karti 1:300.000 (Jogan, 2001a) (Sl. 2). Sklepamo, da je ta hip mreža ustreznih habitatov smrdljive kukavice še dovolj gosta, da lahko govorimo o viabilni populaciji.

Ekološke razmere na rastiščih

Smrdljiva kukavica je vezana na globlja in naravno hranljiva tla, tako kot njej sorodni geofiti, ki vsako leto pridelajo znaten delež biomase nadzemnih organov. Takšna tla morajo biti neobremenjena z gnojenjem in drugim vnosom hranilnih snovi, kar pa je danes že redek primer. Ugotovili smo, da na njeno rast ugodno deluje delna zasenčenost, zato jo najdemo pogosto med visokimi steblikami gozdnega roba. V Halozah je splet ugodnih rastnih razmer prispeval k dejstvu, da to zunaj submediterana izginjajočo vrsto najdemo še danes v razmeroma zdravi populaciji. Prva dva pogoja sta ustrezna geološka podlaga in tla – globoka rodovitna evtrična rjava tla na laporjih. Zaradi globljega profila



Sl. 2: Nahajališča smrdljive kukavice *(Himantoglossum adriaticum)* ***v Vinorodnih Halozah, popisana v letih 1998–2000: 1 – Pristava, 2 – Pohorje, 3, 4, 5 – Mali Okič, 6 – Belavšek (Zgornji Leskovec), 7 – Veliki Okič, 8 – Zgornje Gruškovje, 9 – Trdobojci, 10 – Velika Varnica 1, 11 – Velika Varnica 2.***
Fig. 2: Localities of the Adriatic Lizard Orchid *(Himantoglossum adriaticum)* ***at Vinorodne Haloze, surveyed during 1998–2000: 1 – Pristava, 2 – Pohorje, 3, 4, 5 – Mali Okič, 6 – Belavšek (Zgornji Leskovec), 7 – Veliki Okič, 8 – Zgornje Gruškovje, 9 – Trdobojci, 10 – Velika Varnica 1, 11 – Velika Varnica 2.***

imajo tla tudi večjo vodno kapaciteto, so razmeroma dobro preskrbljena s hranilnimi snovmi in imajo nevtralno do rahlo bazično kemijsko reakcijo. Naslednji pogoj za uspevanje vrste je tradicionalna ali ekstenzivna raba travišč, to je paša ali košnja enkrat ali dvakrat na leto brez dognojevanja. K ugodnim razmeram pripomore tudi ustrezna klima, ki jo definirajo kot zmerno-celinsko ali subpanonsko podnebje vzhodne Slovenije: poletja so razmeroma suha in vroča, vegetacijska sezona je dolga. Torej dejavniki, ki jih označimo kot "toplo-vlažno-rodovitno". Rastišča so v celoti vezana na travišča nevtrofilne mezofilne združbe srednjeevropske razširjenosti *Onobrychido viciifoliae-Brometum* T. Müller 1966, ki spada v skupino "z orhidejami bogatih suhih travišč" (Oberdorfer & Korneck, 1978) iz zveze *Mesobromion erecti* (Br.-Bl. & Moor 1938) Oberd. 1957 (red *Brometalia erecti*). Če so travniki razviti v visokodebelnem sadovnjaku (zasenčenost!), je gostota smrdljivih kukavic lahko zelo visoka.

Naravovarstvena problematika in zaključki

Suhi in polsuhi ekstenzivni travniki so v Srednji Evropi med najbolj ogroženimi habitati (Wolkinger & Plank, 1981; Luick, 1998). Posledica spremenjenega gospodarjenja je upadanje površine teh habitatov in z njo povezana fragmentiranost in izolacija (Keymer & Leach, 1990; Kahmen *et al.*, 2002; Wallis DeVries *et al.,* 2002). V "nerazvitih" Halozah se je tradicionalno ekstenzivno gospodarjenje ohranilo vse do danes. Zaradi strmih pobočij tega dela Haloz ni prišlo do večje intenzifikacije – razen v dolinah. Mreža teh habitatov se je v zadnjih dvajsetih letih bistveno skrčila predvsem zaradi opuščanja. Ker pa vrsta *H. adriaticum,* ki je visoka steblika in dolgo živeča trajnica, tolerira delno zasenčenost, je ta sprememba v gospodarjenju (sekundarna sukcesija) kratkoročno ne zmoti. Dolgoročno seveda pomeni postopno ugašanje haloške populacije.

Pokrajina Vinorodnih Haloz je na gosto prepredena s suhimi travniki združbe *Onobrychido viciifoliae-Brometum*, marsikje so na njih posajeni sadovnjaki, tako da so le-ti v gosti mreži. Kljub majhnim, toda med seboj povezanim površinam, ne delujejo fragmentirano in so zato populacije tudi najbolj občutljivih vrst, kot so orhideje, še viabilne. O tem priča njihova številčnost. Veliko študij se ukvarja z analizo viabilnosti populacij (Amler *et al.*, 1999; Possingham *et al.*, 2001), nekateri prinašajo celo praktične nasvete za naravovarstvo (Lindenmayer *et al.*, 2003; Henle *et al.*, 2004). Za *H. adriaticum* v Vinorodnih Halozah menimo, da gre za izolirano populacijo, ki je viabilna prav zaradi sledečih znakov: (1) najdenih je bilo razmeroma veliko število primerkov, (2) na območju je gosta mreža ustreznih habitatov in (3) ugotovljena je bila pogostost najbolj senzibilnih vrst teh habitatov, orhidej iz rodov *Ophrys* in *Orchis,* ki smo jih zabeležili pri terenskem delu. Ugotavljamo, da so primerni habitati med seboj oddaljeni od nekaj metrov do nekaj deset metrov, nikakor pa ne dlje kot nekaj sto metrov. To pa je dovolj majhna razdalja za navzkrižno opraševanje z insekti kot tudi raznašanje lahkih in številnih semen z vetrom.

Zakaj je vrsta dejansko izginila v preostalem delu areala zunaj submediterana? Znano je, da populacije posamezne vrste lahko ugasnejo tudi takrat, kadar kako-

vost habitata ostane nespremenjena, če fragmentacija tega habitata postane prevelika (Hanski, 1999). Verjetno je, da se je dogodilo prav to, saj poznamo v okolici znanih nahajališč (Bizeljsko, Zasavje) kar nekaj "potencialno primernih" rastišč za smrdljivo kukavico, ki pa kljub našim poskusom, da bi jo našli, tam ni bila potrjena. Kakšno je bilo stanje pred pol stoletja zaradi pomanjkljivih podatkov, ni znano, tako da je trend upadanja težko določiti. Kako je bilo pred dobrimi 30 leti, lahko sklepamo iz člankov Petkovška (1970, 1974, 1977), ki opisuje suhe travnike s Štajerske in Dolenjske kot zelo pogoste in danes redke vrste omenja brez posebnih poudarkov. Kaj pa pred 100 leti? Cilenšek (1896) npr. opisuje navadno kukavico (*Orchis morio*), ki je indikator suhih, pustih travnikov, kot travniškega škodljivca in njene populacije na enem travniku prešteva v stotine in tisoče. Zaradi večje izolacije in fragmentiranosti suhih travnikov kot v Vinorodnih Halozah je v celinskem delu Slovenije vedno redkejša vsaj še ena vrsta kukavičevk, steničja kukavica (*Orchis coriophora*). Ta naj bi recentno uspevala le še na 2 nahajališčih ob Krki (Škornik, 2000; N. Jogan, *ustno),* številna Hayekova (1956) nahajališča pa so že desetletja nepotrjena.

Od kod smrdljiva kukavica v Halozah? Eden od možnih virov za prenos te vrste iz submediteranskega prostora v ta del Slovenije (in bližnje Hrvaške) je transhumanca, ki jo omenjajo ustni viri. Ovce so prihajale iz jugozahoda in s svojih zimskih paš verjetno prenašale semena submediteranskih rastlin. Seveda je to le nepotrjena hipoteza, ki pa jo je po prekinitvi transhumance le težko potrditi, dejstvo pa je tudi, da imajo orhideje zelo drobna semena, katerih prenos z dlako je vprašljiv. Pojavljanje še nekaterih drugih submediteranskih vrst *(Limodorum abortivum, Ruscus aculeatus, Muscari comosum)* v Halozah potrjuje sicer neznaten, a zaznaven submediteranski vpliv na tem območju.

Prav gotovo je rešitev za obstoj populacije smrdljive kukavice in drugih travniških orhidej v Vinorodnih Halozah razglasitev območja Natura 2000 in povezava s SKOP-om (Slovenskim okoljsko-kmetijskim programom). Slednji predvideva subvencijo košnje, ki je še prav posebno zaželena na zelo strmih haloških pobočjih. Suhi travniki pomenijo bogat genski sklad tudi za druge, sicer v Srednji Evropi močno lokalizirane in občutljive vrste, tako npr. za mačja ušesa *(Ophrys sphecodes, O. holosericea)* in druge orhideje: *Anacamptis pyramidalis, Spiranthes spiralis, Traunsteinera globosa* ipd. Prav gotovo pa ostaja jadranska smrdljiva kukavica prvovrsten indikator stopnje ohranjenosti tradicionalne kulturne krajine slovenskega "celinskega" gričevja v srednjeevropskem prostoru.

OCCURRENCE OF THE ADRIATIC LIZARD ORCHID *HIMANTOGLOSSUM ADRIATICUM* H. BAUMANN AT HALOZE (NE SLOVENIA)

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SUMMARY

The occurrence of Himantoglossum adriaticum *H. Baumann in Slovenia is discussed. The authors distinguish between sub-Mediterranean part and the rest of its Slovenian range. Species is common in sub-Mediterranean part, but rare and declining in the rest of its Slovenian range. It was established that isolated and dispersed localities, not confirmed for many decades, had become extinct, due to habitat fragmentation and its consequences. In the area of Vinorodne Haloze (NE Slovenia), 11 localities with 450 flowering specimens have been found and monitored in the last 5 years. The newly discovered population at Vinorodne Haloze is thought to be viable, due to dense network of small patches of its habitats –* Mesobromion *grasslands and appropriate warm climate and soil conditions. The possible origin of this population via "moving corridors" of transhumance is also discussed.*

Key words: *Himantoglossum adriaticum*, Vinorodne Haloze, NE Slovenia, range, *Mesobromion*

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EOCENSKI NUMULITI PRI DOLNJEM MLINU V VIPAVSKI DOLINI, JZ SLOVENIJA

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IZVLEČEK

Pri Dolnjem mlinu na lokaciji Brenk v Vipavski dolini nedaleč od Ajdovščine so bili v kosu apnenca iz flišnih olistostrom ugotovljeni naslednji numuliti: Nummulites ornatus, N. bombitus, N. haymanensis in N. subdistans. *Drugod v apnencih jugozahodne Slovenije te združbe ne poznamo,* N. haymanensis *pa je bil sploh prvič najden v Sloveniji.*

Ključne besede: numuliti, eocen, fliš, Slovenija

NUMMULITI EOCENICI A DOLNJI MLIN NELLA VALLE DEL VIPACCO, SLOVENIA SUD-OCCIDENTALE

SINTESI

Non lontano da Aidussina (Ajdovščina), nella località di Brenk in prossimità di Dolnji Mlin, in un blocco calcareo proveniente da olistostromi di flysch sono stati ritrovati i seguenti nummuliti: Nummulites ornatus, N. bombitus, N. haymanensis *e* N. subdistans. *Tale associazione di fossili non è stata trovata in altri calcari della Slovenia sud-occidentale. Per* N. haymanensis *si tratta del primo ritrovamento in tale regione.*

Parole chiave: nummuliti, Eocene, flysch, Slovenia

UVOD

V sivem do rjavosivem kosu apnenca, najdenem v flišnih olistostromah pri Dolnjem mlinu, ledinsko ime Brenk, malo pred Pipanovo steno (Sl. 1), so bili odkriti numuliti. Na tem prostoru se ponekod menjavajo tudi več deset metrov debele olistostromne plasti z različnimi kosi od temno do svetlo sivih apnencev, zrnatih apnencev pa tudi gostih sivih apnencev. Kosi so iz kamnin različnih starosti, deloma zelo verjetno paleocenski, veliko je ilerdijskih in tudi cuisijskih. Redkejši kosi so morda celo iz mezozojskih kamnin. Pri Brenku pod debelo olistostromno plastjo ležita temneje siv laporovec in rjav peščenjak. Olistostrome so vzrok za selektivno erozijo, zaradi katere zbujajo pozornost nekateri griči v Vipavski dolini. Nekoliko severneje od Brenka sta na takšnih gričih vasici Ustje in Vipavski križ, griči so tudi pri Dobravljah, Kukanjah, Vrtovinu in drugod.

MATERIAL IN METODE

V flišnih sedimentih so med turbiditnimi plastmi pogosto olistostrome, v katere so prihajali tudi kamninski kosi iz starejših plasti. Preiskave teh kosov dajo večkrat zanimive rezultate o tem, katere kamnine so bile v času nastajanja fliša razgaljene in tudi že litificirane. V kosih so včasih fosili, ki jih drugod še nismo našli.

V kosu apnenca iz olistostrom pri Dolnjem mlinu so bili preiskani numuliti. Ker je apnenec trda kamnina, je mogoče orientirane preseke hišic dobiti samo z udarci s kladivom. Pokazalo se je, da je favna, ugotovljena v preiskanem kosu, tudi v tamkajšnjih olistostromnih kosih redka.

REZULTATI

Starost omenjenega kosa apnenca z numuliti iz Brenka je spodnji cuisij, najbrž najstarejši del te stopnje, medtem ko je fliš mlajši. Ugotovljene so bile vrste *Nummulites ornatus* Schaub, *Nummulites bombitus* Hottinger, *Nummulites haymanensis* Schaub in *Nummulites subdistans* De la Harpe. *N. ornatus* je znan od zgornjega ilerdija do bazalnega cuisija, vendar nobena druga ugotovljena vrsta ni ilerdijska. Glede na to, da je *N. ornatus* znan samo še iz začetka cuisija, moramo apnenec iz Brenka postaviti v bazalni del spodnjega cuisija v biocono SBZ 10.

Opisi numulitov

***Nummulites ornatus* De la Harpe, 1926**
(Tabla 1, Sl. 1)

1951 *Nummulites praecursor ornatus* nov. ssp.– Schaub, 139, sl. 157–158, tab. 3, sl. 12–13
1973 *Nummulites ornatus* Schaub, 1951 – Kapellos, 82–83, sl. 186–191, tab. 40, sl. 6, tab. 45, sl. 3–4
1981 *Nummulites ornatus* Schaub, 1951 – Schaub, 118–119, tab. 5, sl. a, b, tab. 27, sl. 12–17
1998 *Nummulites ornatus* Schaub 1951 – Tosquella & Serra-Kiel, 54, tab. 4, sl. 5–8

Zavoji se enakomerno višajo. Zavojni rob je precej močan. Septa so usločena in nagnjena. Premer hišice je okrog 9 mm. Ta vrsta je znana iz zgornjega ilerdija in največkrat iz bazalnega cuisija (Schaub, 1981). Našli so jo v Franciji, Španiji in Švici, od koder izhaja holotip (Schaub, 1951). Pri nas jo poznamo iz fliša v jugozahodni Sloveniji (Pavlovec, 1982).

Pri Ustjah v Vipavski dolini in v Postojni je bila v srednjecuisijskem flišu najdena tej vrsti podobna oblika; označili smo jo *Nummulites* aff. *ornatus* (De Zanche *et al.*, 1967; Pavlovec, 1981). Od pravega *N. ornatus* se loči po velikosti, številu zavojev in ornamentaciji na površini hišice. Še vedno ni rešeno vprašanje, ali je to nova vrsta, ker nimamo dovolj dobro ohranjenih primerkov.

***Nummulites bombitus* Hottinger, 1977**
(Tabla 1, Sl. 2–4)

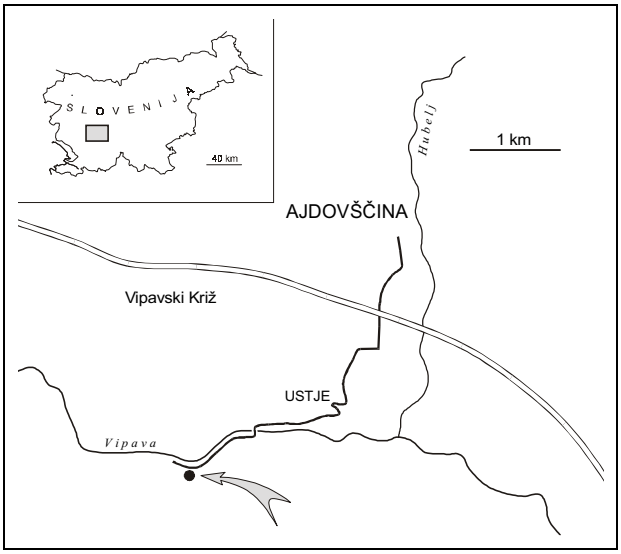
1977 *Nummulites bombitus* n.sp. – Hottinger, 129, sl. 52 a, b, 54, tab. 61
1981 *Nummulites bombitus* Hottinger, 1977 – Schaub, 179, tab. 15, sl. s, tab. 45, sl. 27–35
1998 *Nummulites bombitus* Hottinger, 1977 – Tosquella & Serra-Kiel, 98–99, tab. 17, sl. 8–10

Hišica je tanka, zavoji se hitro višajo. Septa so v spodnjem delu pogosto skoraj ravna, zgoraj so močno usločena nazaj, ponekod so v celoti srpasta. Zelo podobna je vrsta *Nummulites spirectypus* Doncieux. Zlasti zadnji zavoj se pri *N. spirectypus* nekoliko hitreje dvigne kot pri *N. bombitus,* ki ima malo redkejša in precej srpasta septa ter malo manjšo hišico. Razlika je v starosti, *N. spirectypus* je srednjeilerdijski, *N. bombitus* pa v conah SBZ 10 in 11 (= Shallow Benthic Zones; Serra-Kiel *et al.*, 1998), kar je spodnji in srednji cuisij.

Obe omenjeni vrsti se težko ločita med seboj. Čeprav Hottinger (1977) navaja razlike med obema, nejasnosti ostajajo. *N. bombitus* naj bi imel tanjši zavojni rob in počasneje naraščajoče zavoje. Na risbah in fotografijah v publikacijah Hottingerja (1977) in Schauba (1981) te razlike niso prepričljive. Prav tako ni jasna gostota sept. Na nekaterih slikah so gostejše pri eni vrsti, na drugih pri drugi.

Obe podobni vrsti smo primerjali tudi z najdišč pri Planini, kjer je bil v olistostromah odkrit *N. spirectypus* in iz kamnoloma Laže pri Razdrtem, kjer je bil v apnencu najden *N. bombitus.* Najbolj značilni primerki z obeh najdišč se ločijo po naslednjih znakih:

- *N. spirectypus* iz Planine ima hitreje naraščajoče zavoje kot *N. bombitus* iz Laž, čeprav so pri zadnjem nekateri zavoji tudi precej visoki;
- septa so pri *N. spirectypus* iz Planine nekoliko gostejša kot pri *N. bombitus* iz Laž, vendar je razlika izredno majhna;



Sl. 1: Lega najdišča pri Dolnjem mlinu v Vipavski dolini. Fig. 1: Position of the locality near Dolnji mlin in the Vipava Valley.

- septa so pri *N. spirectypus* bolj upognjena kot pri *N. bombitus* in ponekod pri prvem skoraj srpasta; pri obeh vrstah pa je nekaj anomalij, kar je na splošno pogosto pri takšnih tankih numulitnih hišicah s hitro naraščajočimi zavoji.

Primerek *N. bombitus* iz Laž smo pred časom določili kot *Nummulites irregularis* Deshayes. Ob bogatejšem fosilnem materialu in natančnejšem pregledu se je pokazalo, da se *N. irregularis* loči od numulita iz Laž po bolj usločenih in srpastih septah, po obliki kamric ter po bolj nepravilno potekajočih zavojih.

Vrsto *N. bombitus* so našli v Španiji, Franciji, na Sardiniji, pri Sonnbergu na Koroškem, holotip pa je iz okolice Varne v Bolgariji (Hotinger, 1977; Schaub, 1981). Ti "operkulinoidni" numuliti se tudi pri nas v nekaterih delih apnencev večkrat najdejo v večji množini, tako v apnencih iz olistostrom pri Planini in sedaj pri Brenku. Najbrž so občasno obstajale ugodne razmere za razvoj takšnih oblik numulitov. Zanimivo bi bilo ugotoviti, kakšne so pravzaprav bile te razmere.

***Nummulites haymanensis* Schaub, 1981**
(Tabla 1, Sl. 5)

1951 *Nummulites* sp. aff. *pratti* – Schaub, 201, sl. 301–302
1966 *Nummulites* sp. nov. Haimana (Anatolie) – Schaub, 295, sl. 2
1981 *Nummulites hymanensis* nov. sp. – Schaub, 181–182, sl. 108, 111, tab. 12, sl. d, tab. 66, sl. 1–5, 8–19
1998 *Nummulites haymanensis* Schaub 1981 – Tosquella & Serra-Kiel, 94, tab. 16, sl. 5–6

Ta vrsta je precej podobna obliki *N. subdistans.* Od nje se loči po višjih zavojih in nekoliko redkejših septah. Zavojni rob je tanek. Premer hišice je okrog 12 mm, kar je malo več kot pri vrsti *N. subdistans.*

N. haymanensis je znan iz spodnjega cuisija, na več najdiščih prav iz začetka te stopnje. Holotip izhaja z najdišča Haymana v Turčiji, našli so ga tudi v Španiji (Schaub, 1981).

***Nummulites subdistans* De la Harpe, 1926**
(Tabla 1, Sl. 6–8)

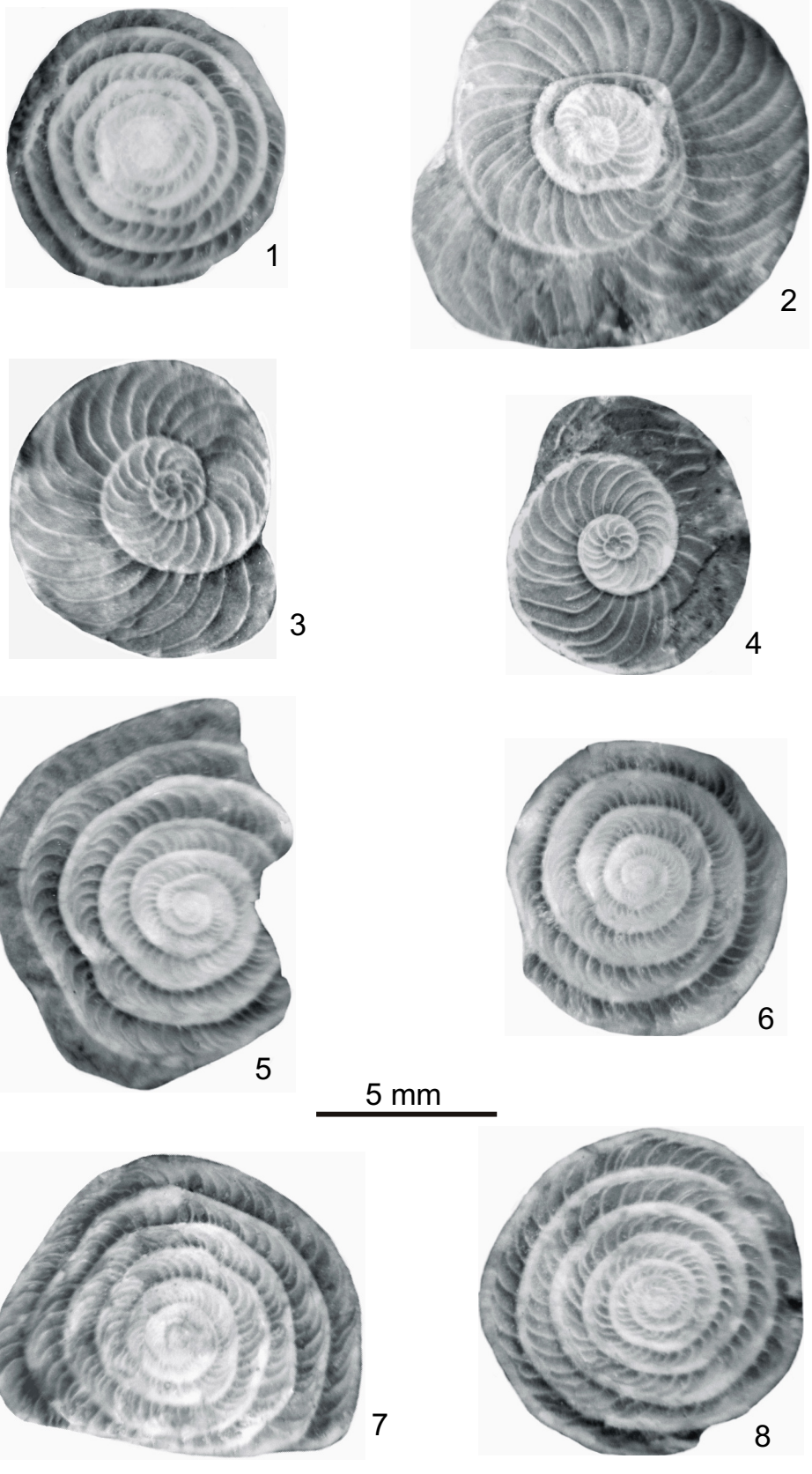
1929 *Nummulites subdistans* De la Harpe – Rozlozsnik, 216, tab. 2, sl. 9, 12, tab. 9, sl. 8
1973 *Nummulites subdistans* De la Harpe (Rozlozsnik), 1926 – Kapellos, 91–92, sl. 223–230, tab. 42, sl. 14–15
1981 *Nummulites subdistans* De la Harpe, 1926 – Schaub, 189–190, sl. 111–112, tab. 12, sl. a, tab. 65, sl. 1–8

Mikrosferična generacija ima pri premeru 10 mm 8 zavojev, ki se enakomerno počasi višajo. Srpasta septa so gosta. Zavojni rob je precej tanek. Megalosferična oblika ima pri premeru 3 mm 3 zavoje. Protokonh je majhen in okrogel.

Ta vrsta je znana od začetka cuisija do srednjega cuisija oziroma iz cone SBZ 10 (Serra-Kiel *et al.*, 1998). Našli so jo v Italiji, v okolici Salzburga v Avstriji, v Pirenejih in v Švici, od koder izhaja holotip (Schaub, 1981). Ugotovljena je bila tudi v flišnih plasteh jugozahodne Slovenije (Pavlovec, 1982).

Tabla 1 / Plate 1:

Sl. 1 / Fig. 1: *Nummulites ornatus* ***De la Harpe; oblika B / B form.***
Sl. 2 / Fig. 2: *Nummulites bombitus* ***Schaub; oblika B / B form.***
Sl. 3, 4 / Figs. 3, 4: *Nummulites bombitus* ***Schaub; oblika A / A form.***
Sl. 5 / Fig. 5: *Nummulites haymanensis* ***Schaub; oblika B / B form.***
Sl. 6–8 / Figs. 6–8: *Nummulites subdistans* ***De la Harpe; oblika B / B form.***


1
2
3
4
5
6
5 mm
7
8

RAZPRAVA

Ponovno se je pokazalo, da so v olistostromnih kosih na sekundarnem mestu včasih fosili in stratigrafski horizonti, ki jih na primarnem mestu ne poznamo. Tudi v kosu iz Dolnjega mlina je združba numulitov *N. ornatus, N. bombitus, N. haymanensis* in *N. subdistans,* ki je prvič ugotovljena v Sloveniji. Vrsta *N. haymanensis* pa je v Sloveniji najdena sploh prvič. To pomeni, da še ne poznamo vseh stratigrafskih horizontov in biocon in tudi ne vse favne.

Po vrsti *N. ornatus* bi lahko sklepali na zgornje-ilerdijsko ali spodnjecuisijsko starost apnenca iz olistostrome pri Dolnjem mlinu. Nobena druga ugotovljena vrsta pa ni znana iz ilerdija. Zato moramo kos apnenca iz Dolnjega mlina postaviti v bazalni del spodnjega cuisija, v biocono SBZ 10. Flišne plasti, ki vključujejo te olistostrome, so mlajše.

EOCENE NUMMULITS FROM DOLNJI MLIN IN THE VIPAVA VALLEY (VIPAVSKA DOLINA), SW SLOVENIA

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SUMMARY

Near Dolnji mlin with microlocality Brenk, situated near Ajdovščina in the Vipava Valley, SW Slovenia, the following species of nummulits have been found in grey limestone from flysch olistostroms: Nummulites ornatus S*chaub,* N. bombitus *Hottinger,* N. haymanensis S*chaub and* N. subdistans *De la Harpe. All these forms are Cuisian, except for* N. ornatus*, which is also known from the Upper Ilerdian. However, as* N. haymanensis *is a Lower Cuisian species and in several localities even originates from the beginning of this stage, the limestone from Brenk can be placed in the earlier older part of Lower Cuisian in the SBZ 10. It is interesting that such group of fossils have not been found in limestones from other localities in south Slovenia. In fact,* N. haymanensis *was found here for the very first time in Slovenia. The Ilerdian* N. spirectypus *and Cusian* N. bombitus *present a considerable problem, considering that they are very similar species. A detailed analysis will be needed to define the distinction between them.*

Key words: nummulits, Eocene, flysch, Slovenia

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DELO NAŠIH ZAVODOV IN DRUŠTEV
ATTIVITÀ DEI NOSTRI ISTITUTI E DELLE NOSTRE SOCIETÀ
ACTIVITIES BY OUR INSTITUTIONS AND ASSOCIATIONS

OSNOVNE USMERITVE PRI VARSTVU, UPRAVLJANJU IN RABI KRAJINSKEGA PARKA SEČOVELJSKE SOLINE (KPSS)

Sečoveljske soline so območje habitatov redkih, ogroženih in značilnih rastlinskih in živalskih vrst, kjer je zaradi človekovega dolgotrajnega delovanja, nastal tipičen solinski ekosistem. Z Aktom o notifikaciji nasledstva glede konvencij, ki jih je sprejel UNESCO, je Skupščina RS uvrstila Sečoveljske soline v seznam močvirij mednarodnega pomena, zlasti kot prebivališča močvirskih ptic.

Prvi znani dokument, ki omenja Piranske soline, v katere so bile vključene tudi Sečoveljske, oziroma tisti del, ki je bil v lasti samostana, je tako imenovani Placito di Risano iz leta 804 (ing. Koludrovič Ante: Historijsko ekonomski podaci istarsko-trščanskih uglavnom Piranskih solana. Zagreb, 1955). Območje Sečoveljskih solin in polotoka Seča je bilo zaradi izredne ohranjenosti ter znanstvene, kulturno-vzgojne, ekološke in krajinsko-oblikovne vrednosti razglašeno za krajinski park lokalnega pomena. Soline so zaradi etnološke in tehnične dediščine pomemben kulturni spomenik.

Morske soline so tehnološki objekt, ki ga je treba stalno vzdrževati v primernem stanju. Varovalni nasipi solin so istočasno varovalni nasipi površin v zaledju solin, kjer so kmetijske površine, pomembna cestna prometnica, letališče in druge gospodarske dejavnosti. Na južnem delu solin med reko Dragonjo in kanalom Giassi je Muzej solinarstva, ki je kulturni spomenik državnega pomena in katerega delovanje je odvisno od obvladovanja vodnega režima v tem območju.

Naravne in kulturne vrednote območja solin so osnova za načrtovani razvoj gospodarske rabe po načelu "razumne rabe", z vključevanjem interesov lokalnega prebivalstva in s ciljem, da se zagotovijo ustrezne ekonomske razmere za ohranjanje in razvoj parka.

Tradicionalna pridelava soli, ki je ustvarila solinski prostor, s postopki solinarjenja ohranja biotsko raznovrstnost v njem. Način solinarjenja, ohranjen na Sečoveljskih in Strunjanskih solinah, je posebnost v Mediteranu, kar daje naravni morski soli iz Sečoveljskih solin možnost poimenovanja z geografskim poreklom Krajinski park Sečoveljske soline, Slovenija. Soline so edini rudarski pridobivalni prostor v Sloveniji za pridobivanje jedilne soli.

V tehnološkem postopku se pridobivajo dodatni proizvodi s posebnimi lastnostmi, značilnimi za ta prostor: mikroklima, solinsko blato – fango in matična slanica – acqua madre, ki so osnova za obstoj in razvoj visokokakovostnega termalnega turizma z vsemi oblikami talasoterapij, spremljajočimi programi Wellness, edukativnim turizmom, rekreacijo in posebno obliko navtičnega turizma.

Velike površine najdragocenejših habitatov bodo zavarovane pred spremembami vodnega režima. (Foto: I. Škornik)
Large areas of the most valuable habitat types will be protected against changes of the water regimes. (Photo: I. Škornik)

Košnja na Fontaniggah. (Foto: K. Gorišek)
Mowing on the Fontanigge area. (Photo: K. Gorišek)

Pravne podlage za upravljanje KPSS in rabe naravne dobrine

Osnovni pravni akt je Zakon o ohranjanju narave (ZON, Ur. l. RS št. 56, 13. 7. 1999). Posebni pravni akti za območje KPSS so še:

A) Uredba o Krajinskem parku Sečoveljske soline (Ur. l., št. 29, 20. 4. 2002), ki temelji na določilih Zakona o ohranjanju narave in Odločbi o izbiri skrbnika KPSS št. 35416–12100, 14. 9. 2000, MOP, UVN (v nadaljnjem: Uredba).
B) Odlok o razglasitvi Muzeja solinarstva za kulturni spomenik državnega pomena (Ur. l. št. 29, 20. 4. 2002) (v nadaljnjem: Odlok).
C) Koncesijska pogodba med koncedentom (Republiko Slovenijo) in koncesionarjem (Soline Pridelava soli d.o.o.)

S koncesijsko pogodbo je Republika Slovenija celotno območje "državnega parka" podelila v upravljanje enemu upravljalcu, to je podjetju SOLINE Pridelava soli d.o.o.

Območje KPSS je razglašeno kot prvo slovensko močvirje na seznam močvirij mednarodnega pomena pod varstvom Ramsarske konvencije o močvirjih in je predlagano za uvrstitev v omrežje posebej varovanih območij na območju Evropske unije; po določilih Ptičje direktive se uvršča območje Lere in Fontanigge, po določilih Habitatne direktive pa le območje Fontanigge.

A) Uredba o Krajinskem parku Sečoveljske soline (Ur. l. št. 29, 20.4.2002)

Uredba o KPSS opredeljuje določila varstvenega režima in conacijo območja ter določa dejavnosti, ki so dopustne za posamezne cone v KPSS. Uredba temelji na določilih ZON-a, ki pri definiranju kategorij zavarovanih območij sledi razdelitvi IUCN-ovih upravljalskih kategorij za zavarovana območja. Po IUCN-ovi delitvi sodi KPSS v kategorijo IV (po ZON-u: "Upravljani naravni rezervat"): "Zavarovano območje, kjer z aktivnimi upravljalskimi posegi zagotavljamo ohranitev razmer za obstoj habitatov in zahtev specifičnih vrst".

Namen varstva po Uredbi je zavarovanje območja naravne vrednote Sečoveljskih solin in ohranitev biotske raznovrstnosti. Zavarovanje in ohranitev naravne vrednote in biotske raznovrstnosti se zagotavlja **z izvajanjem varstvenih režimov in pravil ravnanja v parku.** Park je razdeljen na tri varstvena območja. Za vsa tri velja, da je prepovedano izvajati posege, opravljati dejavnosti ali ravnati na način, ki bi lahko škodljivo vplival na naravne vrednote in biotsko raznovrstnost v parku in spreminjal ali ogrožal njegovo ekološko, biotsko ali krajinsko vrednost (3. člen). Podrobneje so prepovedi po posameznih območjih opredeljene še v 4., 5. in 6. členu.

V 11. členu so glede na posamezno varstveno območje opredeljene tudi dejavnosti, ki jih je v KPSS dovoljeno opravljati. V prvem varstvenem območju ni dovoljeno opravljanje nobenih gospodarskih dejavnosti, v drugem območju se opravlja tradicionalno solinarstvo, druge dejavnosti pa le, če ne ovirajo varstva naravnih vrednot v parku oziroma dejavnosti tradicionalnega solinarstva. V tretjem varstvenem območju se poleg varstva naravnih vrednot kot prednostne uvrščajo tudi tradicionalni način rabe in dejavnosti, če se ne opravljajo v obsegu in na način, ki bi ogrožal naravno ravnovesje v parku.

B) Odlok o razglasitvi Muzeja solinarstva za kulturni spomenik državnega pomena (Ur. l. št. 29, 20. 4. 2002)

Območje Muzeja solinarstva je določeno z aktom o razglasitvi Muzeja solinarstva za kulturni spomenik državnega pomena (9. člen Uredbe in Odlok o razglasitvi Muzeja solinarstva za kulturni spomenik državnega pomena). Zavarovano območje po tem Odloku je namenjeno:

- trajni ohranitvi kulturnih, tehniških, etnoloških, krajinskih, likovnih in zgodovinskih vrednot,
- ohranjanju tradicionalnega solinarstva in pridobivanju soli po srednjeveških postopkih,
- ohranjanju pričevalnosti kulturnega spomenika,
- prezentaciji kulturnih vrednot *in situ,* v tisku in drugih medijih,
- muzejski dejavnosti,
- znanstveno-raziskovalnemu delu,
- učno-demonstracijskem delu.

Za spomenik velja varstveni režim, ki je opisan v 4. členu Odloka.

Cilji upravljanja v KPSS

Dolgoročni cilji so usmerjeni k varovanju in trajnemu ohranjanju naravnih vrednot in s tem biotske raznovrstnosti Sečoveljskih solin, ohranjanju kulturne dediščine in značilnosti obmorske kulturne krajine Slovenske Istre. Za uresničitev teh ciljev je treba ohraniti:

- solinarstvo kot gospodarsko dejavnost, ki je izoblikovala to območje,
- pestri solinski ekosistem in njegove habitatne tipe, na katere se veže značilna biotska raznovrstnost,
- tradicionalni proizvodni proces in tehnologijo na sedanjem obsegu površin.

Vsebina varstva, upravljanja in rabe KPSS (temeljne vsebine)

Varstvo in upravljanje z naravno vrednoto

- habitati in vrste (zbiranje podatkov o habitatih in vrstah ter njihovem stanju),
- varstvo habitatov in vrst,
- sonaravno upravljanje z naravno vrednoto (npr. solinarska dejavnost, gojenje rastlin itd.),
- upravljanje, obnova in vzdrževanje habitatov (npr. uravnavanje vodnega režima, nadomestni habitati, umetna gnezdišča, košnja, obnova nasipov in infrastrukture itd.).

Ohranjanje in varstvo kulturne dediščine in krajine
- podpora ohranjanju tradicionalne rabe v krajini (solinarska dejavnost) ter ohranjanje stavbne in tehniške dediščine (npr. preprečitev poškodb) v sodelovanju z inštitucijami pristojnimi za varstvo kulturne dediščine,
- ohranjanje tradicionalnih habitatov in njihovih vrst (solinski bazeni, nasipi...).

Vzdrževanje in obnova infrastrukture za obisk KPSS
- center za obiskovalce,
- interpretacijske in informacijske točke,
- strokovno vodstvo,
- druga infrastruktura (npr. klopi, table, koši za odpadke…).

Infrastruktura za omogočanje (pasivne) rekreacije
- vzdrževanje obstoječih ter načrtovanje in izvedba novih poti za obiskovalce (pešpoti, kolesarske poti).

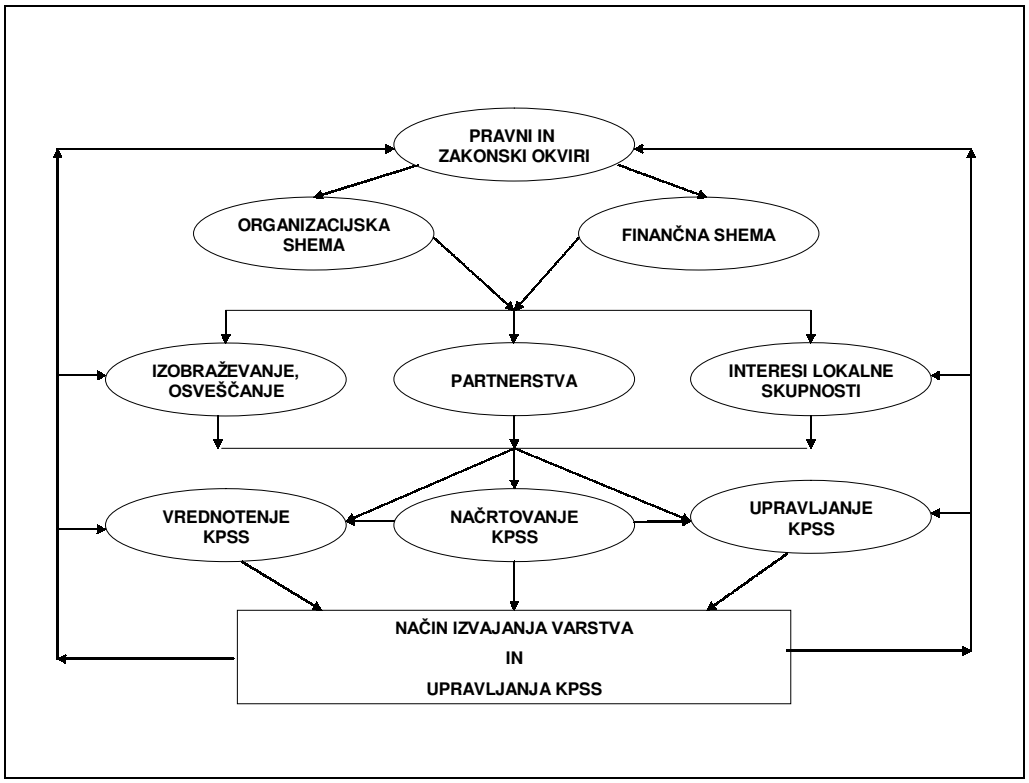
Raziskave, monitoring in osveščanje
- predvsem v sodelovanju z zunanjimi sodelavci/partnerji in lokalno skupnostjo.

Načrtovanje podlag za razvoj sonaravnega turizma
- priprava usklajenih strokovnih podlag za razvoj turističnih dejavnosti (npr. termalni turizem, privezi, ponudba hrane in pijače, kulturne prireditve...).

Način varovanja, upravljanja in rabe

Osnovna shema varovanja in upravljanja parka je prikazana na spodnji skici. Pravni in zakonski okviri so osnova za pripravo organizacijske in finančne sheme upravljanja parka.

Polojnik** (Himantopus himantopus**) je ena najpomembnejših gnezdilk na Sečoveljskih solinah. (Foto: I. Škornik)
Stilt** (Himantopus himantopus**) is one of the most important breeding species of the Sečovlje Salina. (Photo: I. Škornik)



Posebna pozornost je dana izobraževanju in osveščanju sodelavcev parka, lokalne skupnosti in drugih dejavnikov v prostoru, vzpostavljanju partnerskih povezav z njimi in upoštevanju interesov lokalne javnosti. S tem bo zagotovljeno sodelovanje lokalne in druge zainteresirane javnosti (deležnikov) v procesu varovanja in upravljanja parka. Posebno pozornost je treba nameniti odnosu gospodarskega dela upravljanja z območjem (predvsem proizvodnja soli, muzejska dejavnost, turizem, vodno gospodarstvo…), sodelovanju z drugimi organizacijami in združenji (občinske strukture, lokalna skupnost, lokalna turistična združenja, nevladne organizacije…) ter raziskovalno-izobraževalnemu delu.

Viri financiranja KPSS

Po koncesijski pogodbi so med viri financiranja omenjeni državni proračun, prihodki od prodaje blaga in storitev, vstopnine v KPSS, donacije in dotacije ter drugi viri, kot npr. parkirnina. Posebej pomemben finančni vir so sredstva, ki so bila pridobljena v okviru projekta LIFE Nature: "Ohranitev ogroženih vrst in habitatov v Krajinskem parku Sečoveljske soline." Cilj projekta je omogočiti učinkovito vzdrževanje razmer za obstoj ogroženih habitatov in varstvo vrst v Sečoveljskih solinah.

Kratek prikaz projekta LIFE Nature

Za vzdrževanje ekološkega značaja Sečoveljskih solin so sredstva iz projekta LIFE Nature namenjena za naslednje akcije:

- izdelava načrta upravljanja,
- ukrepi za nadzor in uravnavanje vodnega režima ter vzdrževanje nasipov (obnova dela nasipov, redno vzdrževanje nasipov),
- ukrepi za omejitev motenj s strani človeka in kopenskih plenilcev (ureditev robnih jarkov),
- ureditev nadomestnih habitatov (sipine za čigre, otočki in nasipi za gnezdenje),
- osveščanje javnosti in promocija območja (vključno z iniciativo za nova delovna mesta za lokalno prebivalstvo, čezmejno sodelovanje z zavarovanimi območji itd.),
- promocija pomena in upravljanja potencialnega območja v okviru evropskega omrežja naravovarstveno pomembnih območij Natura 2000.

Pričakovani rezultati

- 2000 m^2 najdragocenejših habitatov bo zavarovano pred nekontroliranimi spremembami vodnega režima,
- 5000 m^2 trenutno naravovarstveno nezanimivih površin bo spremenjeno v gnezdišče redkih vrst,
- izkopanih bo 6500 m obrobnih jarkov (okoli 100 ha bazenov), da se onemogoči dostop kopenskim plenilcem,
- 18000 m nasipov bo redno košenih, 9000 m pa obnovljenih in vzdrževanih,
- urejenih bo 50 ha novih potencialnih gnezdišč za solinske ptice in druge vrste.

Andrej Sovinc

XI EUROPSKI KONGRES IHTIOLOGA TALLINN, ESTONIJA (6.-10. RUJNA 2004)

U razdoblju 6-10. rujna 2004. godine je održan kongres ihtiologa Europe u Tallinnu (Estonija) u organizaciji Estonskog morskog instituta (Estonian Marine Institute) pri Sveučilištu u Tartuu (www.sea.ee). Na kongresu je sudjelovalo preko 300 stručnjaka ihtiologa iz 28 europskih i 11 vaneuropskih država koji su tijekom 5 dana izmjenjivali rezultate svojih istraživanja, informacije te planirali i organizirali budući rad. Sve sudionike pozdravili su prof. Toomas Saat, kao domaćin i glavni organizator, te prof. Maurice Kottelat, kao glavni predsjedavajući odbora Europskog ihtiološkog društva (EIS). Tijekom kongresa održana su predavanja i izlaganja u okviru 6 tematskih skupina (A: Taxonomy, systematics, zoogeography and evolution; B: Life history strategies and population ecology; C: Dynamics of fish communities; D: Fish reproduction and development; E: Fish genetics and cytogenetics; F: Fish physiology, immunology, ecotoxicology, parasitology and pathology) i 10 simpozija (G: Fishes in the Baltic sea; H: Alien fish species; I: History of ichthyology in Europe; J: Fish reponses to eutrophication tools to test ecological theory; K: To be or not to be: freshwater fish conservation; L: Integrating approaches to *Cottus* diversity; M: Fish chemoreception; N: FishBase; O: Systematics and biodiversity of the order Cypriniformes (Actinopterygii, Ostariophysi) – a tree of life initiative; X: Fishes of Estonia (only posters)). Na kraju se održala i redovita sjednica europskog ihtiološkog društva na kojoj se načulo da su slijedeći kandidati za održavanje kongresa Portugal, Rumunjska i Hrvatska (Dubrovnik).

Jakov Dulčić

OBLETNICE
ANNIVERSARI
ANNIVERSARIES

ON THE OCCASION OF THE 90TH BIRTHDAY OF DR MIROSLAV ZEI

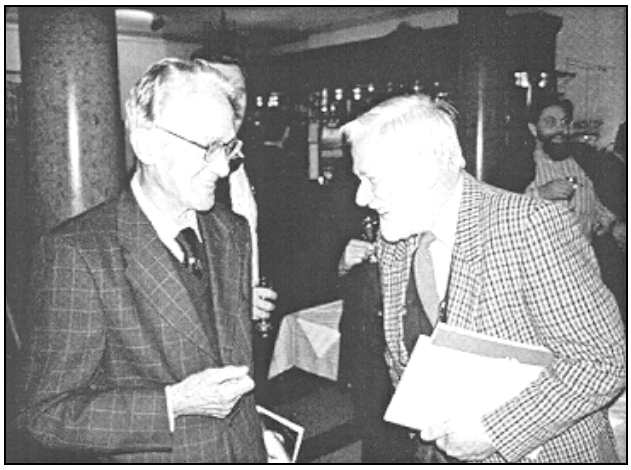
Dr Miroslav Zei was born on 25 July 1914, in the village of Nabrežina near Trieste. In 1920, when his hometown fell under Italy, his family moved to Slovenia owing to growing Fascism, and settled in the town of Maribor, where Dr Zei finished elementary and secondary school. After having taken his *matura* examination in 1932, he enrolled at the University of Ljubljana. As soon as he graduated in biology in 1936, he became active in the fields of ichthyology (the branch of zoology dealing with the systematics, morphology and biology of fishes), biology of fishes and biological oceanography, to which he has remained totally dedicated throughout the 70 years of his scientific and academic work. To him, the sea has presented not only a professional calling, but also one of the greatest loves of his life.

Naturally, it was as early as in his youth that the nostalgic sediment of his childhood recollections of the sea at Trieste, together with the daydreams about wide oceans stimulated by the tales of his father, a mechanic in the Austrian Navy, arose his deep interest for the sea and its secrets. But it was his tutor, Prof. Jovan Hadži, who himself was deeply attached to the sea and its organism, who played the decisive role in directing his career. Soon after his graduation in 1937, Prof. Hadži also helped him to get his first employment at the Institute of Oceanography and Fisheries of Split, where he worked as an assistant and researcher up to 1948.

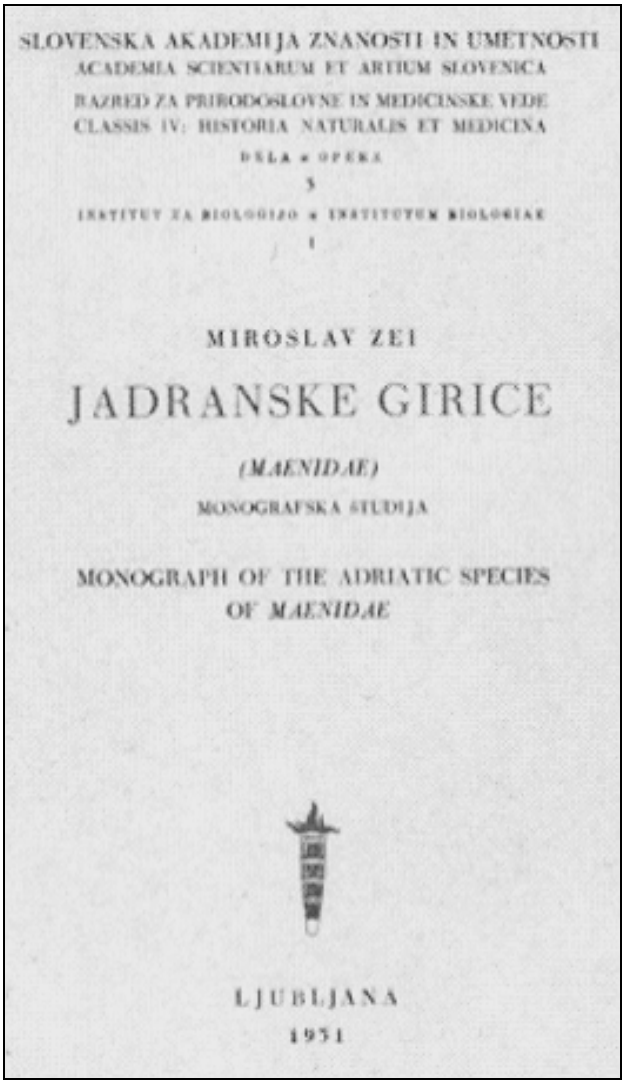
This period – which could also be called the "Split round" – was of vital importance not only for his personal career as a scientist, but also for the branch of ichthyology. It was Dr Zei who introduced a new approach to research on the Adriatic Sea and its abundance of fish species, which led to the development of more reasonably managed fisheries exerting no harmful effects on the fish population. His then research and publication on benthic fish communities presented, as a matter of fact, pioneering steps in the introduction of modern biology of fishes not only to the Adriatic, but also to the wider Mediterranean area. There were two "by-products" of his work and the resulting comprehensive fish collection, both of great importance for basic ichthyology: the revision of the previously unclear classification of the Adriatic species of Maenidae (family Maenidae) and the discovery of sex inversion in the species of Maenidae and in other fish species, with the latter being such a breakthrough that it entered all reference books on ichthyology and zoophysiology.

During the following period (1948–1962), Dr Zei was employed at the Zoological Institute of the Faculty of Natural Sciences of the University of Ljubljana, first as an Associate and since 1954 as a Full Professor. When Prof. Hadži retired in 1956, he became the director of the Institute. In 1960, he was appointed first director of the newly established Institute of Biology, the aim of which was to join in one place all biological programmes of the University of Ljubljana. For two terms, he was also Dean of the Faculty of Natural Sciences. His term of office was marked by his efforts to prevent the relocation of the Department of Biology from the Faculty of Natural Sciences to that of Biotechnology. Unfortunately, his "subversive" action failed, but what he did manage to earn was resentment on the part of the Communist Party and the then Rector. On the other hand, it could be that the outcome of the affair made it easier for him to accept the placement offered to him by the Food and Agriculture Organization of the United Nations.

During the period, he was also very active in the field of education. He was a diligent lecturer of as many as four subjects: comparative anatomy of vertebrates, biology of chordates, evolution, and ecology of the sea. Though very concise and demanding, his lectures were energetic, witty, and interesting. The same goes for his summer courses in marine biology, which he held at the Institute of Marine Biology of the Yugoslav Academy of Sciences and Arts in Rovinj. While heading the Institute from 1951 to 1960 as part-time director, he made several attempts to internationalise its activities, which was far from easy in the times of the former Yugoslavia. Nevertheless, he managed to overcome initial resistance by organising biology courses for students from European universities.



The jubilant Dr Miroslav Zei (left) with Prof. Jože Štirn on the occasion of 30th anniversary of the Marine Biology Station of Piran. (Photo: B. Šuligoj)
Slavljenec, dr. Miroslav Zei (levo) in prof. Jože Štirn na proslavi ob 30. obletnici Morske biološke postaje iz Pirana. (Foto: B. Šuligoj)


SLOVENSKA AKADEMIJA ZNANOSTI IN UMETNOSTI
ACADEMIA SCIENTIARUM ET ARTIUM SLOVENICA
RAZRED ZA PRIRODOSLOVNE IN MEDICINSKE VEDE
CLASSIS IV: HISTORIA NATURALIS ET MEDICINA
DELA • OPERA
3
INŠTITUT ZA BIOLOGIJO • INSTITUTUM BIOLOGICUM
1

MIROSLAV ZEI

JADRANSKE GIRICE

(MAENIDAE)

MONOGRAFSKA ŠTUDIJA

MONOGRAPH OF THE ADRIATIC SPECIES OF *MAENIDAE*

LJUBLJANA
1951

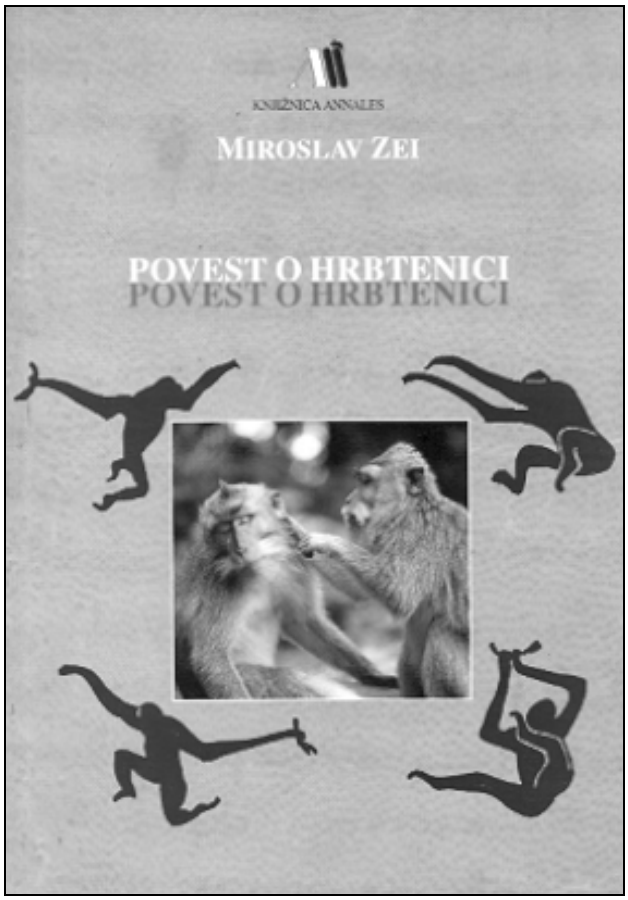
The book of the Adriatic species of Maenidae is one of Zei's most important achievements (1951).
Knjiga o jadranskih giricah je eno izmed Zejevih najpomembnejših dosežkov (1951).

When describing the 1948–1962 period, one should also point out that from 1960 to 1962 Dr Zei headed the Society for Sea Research and Underwater Technology and that he showed no hesitation to use his influence in support of the allegedly venturesome plan of Slovene divers to carry out the first Yugoslav expedition to the Red Sea and Ethiopia, which, needless to say, tuned out to be a great success. By promoting activities that complemented his work in higher education and research and by handing down his enthusiasm to his students, he made it possible that small Slovenia with only a patch of sea has raised a fairly great number of distinguished sea researchers, with four of them having worked for a long time for the UN as heads of important FAO or UNESCO projects conducted in the seas of four continents.

Naturally, it was he who had paved the way. As a FAO expert in fish biology and director of projects for the development of sea fisheries, he worked in Africa for the UN for an uninterrupted period of 13 years. From 1962 to 1970, he was employed on various projects in Ghana, later on (1970–1973) in Tunisia. From 1973 to 1975, he headed the CECAR project, based at the FAO seat in Rome, the aim of which was to provide guidelines to all national fishing organisations along the coast of West Africa, from Morocco to Zaire.

Despite the well-known fact that FAO's employees are in no way obliged to produce scientific publications and have to publish only those results of their work that can be of immediate and practical use for the development of a given national fishery, Dr Zei did not stop writing scholarly books during his "FAO round". Though he published fewer works, they were of great importance for the sea fishery of the whole central Atlantic on the one hand, and for the biology of anchovies and familiar fish species on the other.

In 1975, Dr Zei retired from the UN and moved from Rome to Portorož. Two years later, he started to work



"The backbone story" is one of his latest books (1999).
"Povest o hrbtenici" je ena njegovih novejših knjig (1999).

part-time as the head of Marine Biology Station of Portorož (MBS), a unit of the National Institute of Biology of Ljubljana. It did not take him long to resolve the internal crisis that had affected the Station. His reputation helped the Station to finally gain the funds for the renovation and building of new premises located at Fornače near Piran, to which the MBS moved in 1980. Yet the edifice was also built in order to house the Regional Post-Graduate Centre for the Studies of the Mediterranean Ecology, the establishment of which had been entrusted by the UNESCO's Intergovernmental Oceanic Commission to the University of Ljubljana and the MBS. Unfortunately, the project has not been realised for several quite banal reasons.

While working at the MBS (1977–1983), Dr Zei also tried to introduce applied biological research on fishes that would facilitate the development of the mariculture of fishes and mussels. Unluckily, all his efforts were in vain as they met indifference and irrational opposition. At the same time, he remained extremely active in the academic field. He was re-appointed as Full Professor and between 1976–1985 lectured on ichthyology and biology of fishes at the University of Ljubljana. From 1980 to 1989, he was the principal lecturer at cyclical postgraduate courses on biology of fishes and oceanography held each summer at the Institute of Oceanography and Fisheries of Split and organised by the Yugoslav Institute for International Collaboration for students from African, Asian, and Latin-American countries.

After 1983, when he stopped working at the MBS, his publishing activities increased. Currently, his body of work comprises 42 scientific and around 50 professional articles, 7 scientific books, not to mention as many as 12 titles for the general public, mostly on vertebrates (in particular on fishes), sea fishery, the Adriatic Sea and its flora and fauna. It is the popular science books that have made him well known and respected in the eyes of Slovene readers. Not surprisingly, Slovenes show an incredible love and interest not only for the Adriatic, but also for the sea in general. After all, much of the credit goes to Dr Zei.

In the article that I wrote on the occasion of his 80th birthday, the concluding lines ran as follows: "I would like to express deep gratitude to Dr Zei for sharing his unselfish humanness and enormous knowledge with all of us, as well as with his discipline, fisheries at the Adriatic, Mediterranean and Atlantic, and Slovene science. I sincerely hope that the new Republic of Slovenia will finally acknowledge his merits, thus remedying the disappointment that confirmed the truth of the ancient wisdom: *nemo propheta in patria*." Now, on the occasion of his 90th birthday, I find it appropriate to repeat them. And if necessary, I will do it again when Dr Zei celebrates his 100th birthday. Judging from his strength of character and his will to live, both typical of his Primorska origin, I am absolutely convinced that he will live to see it.

Jože Štirn

IN MEMORIAM

Marjorie Courtenay-Latimer (1907-2004)

Marjorie Eileen Doris Courtenay Latimer, poznata južnoafrička zoologinja koja je otkrila ribu istočnolondonsku latimeriju *Latimeria chalumnae*, umrla je 17. svibnja 2004 godine, u devedesetsedmoj godini života, od upale pluća.

Rođena je u Istočnom Londonu (Južnoafrička Republika) dana 24. veljače 1907. godine. Marjorie je provela svoje djetinjstvo na nekoliko mjesta u Cape Province i Orange Free State te započela školovanje u školi pri Holy Cross Convent u Aliwal North. Courtenay-Latimer je oduvijek pokazivala sklonost prema ornitologiji, botanici te povijesti kulture. Sa 24 godine, postala je prvi kurator Istočnolondonskog Prirodoslovnog muzeja. Tijekom slijedeće četiri desetljeća podigla je taj muzej do nivoa svjetski poznatog i priznatog, poglavito zahvaljujući svojem besprijekornom radu. Veliki dio originalne kolekcije tog muzeja potiče iz arhive njene obitelji, uključujući tu i jaje (izgleda jedino na svijetu) izumrle ptice dodo *Raphus cucculatus*.

Courtenay-Latimer je obožavala rad na terenu, poglavito tijekom vikenda, kada je uglavnom sakupljala materijal za muzejske postave (divlje cvijeće, ptičja jaja te kukce). Tijekom 1935 godine, ona i Eric Wilson su gotovo u potpunosti sami sastavili skelet fosila dicinodonta *Kannemeyeria simocephalus*, dinosaura iz razdoblja trijasa.

Tijekom 1936. godine, provela je dva mjeseca na Ptičjem otoku studirajući život i ponašanje ptica gdje je stekla prijatelje među lokalnim ribarima. U prosincu 1938 (22. prosinca), kapetan koće "Nerine" Hendrik Goosen je kontaktirao Marjorie o neobičnoj ribi koju su on i njegovi ribari ulovili. Kada je Courtenay-Latimer stigla na ribarnicu odmah je uočila jedinstvenu plavu peraju, srebrnkasto-plavo-zelenu boju te ribe, te čudan oblik peraje. Shvativši da je ta jedinka jedinstvena, odmah ju je odnijela u muzej kako bi je konzervirala i pohranila. U svojoj 96 godini još se dobro sjećala tog trenutka te je u jednom razgovoru izjavila: "Odmah sam između ostale ribe lako uočila i izdvojila tu predivnu ribu".

Courtenay-Latimer je potražila pomoć od profesora Jamesa Smitha, profesora kemije na Sveučilištu Rhodes, koji je bio pasionirani ihtiolog. Profesor je potvrdio da se radi o predstavniku davno izumrle skupine resoperki Crossopterygii, iz reda Coelacanthini. To je bila velika senzacija, jer se prije toga smatralo da su posljednji celakantini izumrli još u kretacejskom razdoblju. Otkriće živih celakantina smatra se najznačajnijim zoologijskim otkrićem u prošlom stoljeću u novijoj povijesti biologije i ima višestruku znanstvenu važnost. Vrsta je dobila ime po Marjorie Courtenay-Latimer, koja ju je prva uočila, i po rječici Chalumna blizu koje je jedinka pronađena na dubini od 75 m. Kasnije je utvrđena populacija ove vrste pokraj Komorskog otočja (između Afrike i Madagaskara). Točno 60 godina od prvog otkrića ove vrste predstavnici Coelacanthina nađeni su također 30. srpnja 1998. godine oko 10000 km istočno od ovog nalazišta. Radi se o nalazu pokraj vulkanskog otoka Manado Tua u sjevernom Sulawesiju (Indonezija) i ta vrsta *Latimeria menadoensis* se razlikovala samo u boji (smeđa boja) od *Latimeria chalumnae*.

Courtenay-Latimer je svoje posljednje godine života provela u pisanju knjige o divljem cvijeću i utemeljenju utočišta za ptice Gonubie. Dobila je medalju slobode grada Istočni London 1974. godine, a počasni doktorat 1971. godine pri Sveučilištu Rhodes.

Jakov Dulčić